U. S. DEPARTMENT OF THE INTERIOR

Preliminary Draft

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT ONSHORE OIL AND GAS LEASING IN OREGON

Prepared by

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V. Mitigation of Environmental Impacts of Oil and Gas Leasing

Many of the mitigative measures presented in this section would initially be brought to bear during formulation of the Management Framework Plan, and subsequent mineral activity planning, as a means of reconciling environmental and land use conflicts as discussed in Section I E. In addition, compliance with current Departmental and Bureau regulations for surface protection and reclamation, and Federal and State environmental laws and standards, provides further mitigation, or more precisely, prevention of impacts. Finally, before exploration permits or oil and gas leases are issued, environmental analyses are conducted to determine the extent of environmental impact, and how best to mitigate it. Mitigating measures identified in the analyses are implemented through permit and lease stipulations and on-the-ground administration.

All of the foregoing measures constitute the administrative framework within which mitigation is accomplished. Specific recommended mitigation measures, <u>most of which are currently followed</u>, are presented in the following parts for each resource component.

A. Ecological Interrelationships

In the following parts of this section, measures are described for mitigating the impacts of oil and gas operations on individual components of the environment. Collectively, these measures represent actions which might be taken to maintain stable ecological interrelationships. Consequently, they are not restated in this part.

The effectiveness of mitigative measures generally would be most critical in preserving the natural balance in fragile sub-biomes of low productivity, and in valuable aquatic ecosystems.

B. Physiography, Geology and Minerals

1. Geological Subsidence

If geologic investigations suggest a likelihood of subsidence due to withdrawal of subsurface fluids occurring, then mitigating measures should be initiated.

Within confined systems that are being compacted because of a decrease in fluid pressure, compaction and subsidence can be stopped by injecting water as oil and gas are withdrawn. In zones where saltwater is being disposed, aquifers and aquitards can expand elastically and the land surface may rise slightly if fluid pressures are increased above preconsolidation conditions. Once subsidence has occurred, injection of water will not significantly raise the subsided land. Injection must be done at the time oil is being withdrawn. In the Los Angeles-Long Beach area, waste water is re-injected while oil is being withdrawn. This method has also increased the recovery rate of the oil.

2. Increased Seismicity

Seismicity in areas where oil and gas are found is believed to be the result of naturally occurring tectonic stress. Except for the Rocky Mountain Arsenal well near Denver, Colorado, seismicity resulting from drilling or producing operations is not known to occur. Earthquakes are caused by stresses in the earth's crustal rocks. Some of man's activities could conceivably activate fault slippage but causative forces for major earthquakes are much too large to be attributed to man's

activities. If an oil or gas field is located in an area of frequent earthquakes, a program of seismic monitoring should be conducted to see if the movements are related to periods of withdrawal or injection in the operation of the field. (Personal Communication, V. C. Newton, ODGMI.) Areas of frequent seismic activity can also be precluded from oil and gas drilling.

C. Soils

Soil scientists should help develop stipulations for oil and gas leasing. Their involvement would be one of the most effective mitigating measures for the soils resource. The entire state of Oregon is covered by some type of published soil inventory map and report. Each of these reports contains useful soils information which should be utilized in understanding how the soils will respond to different treatments.

The following discussion of mitigative measures is divided into two parts - General and Specific. The General part is concerned with exploration, development, production and abandonment; and the Specific part covers actions dealing with roads, trails, and building sites. The latter section is very applicable to operations on steep terrain.

1. General

During the exploration phase, the impact on soils due to erosion can be reduced significantly in all sub-biomes by careful pre-planning and by following the guidance included in USDI, BLM Manual 7415 and Oregon State Office Supplement to 7415 (1973). These guidelines provide for reducing the area of impact to a minimum and rehabilitation of disturbed areas as quickly as possible. The width of roads and trails should be limited and the slope and size of cuts controlled as well as the wasting of excavated soil.

Erosion protection should be provided through the use of proper road drainage, road surfacing, water bars, mulching, and seeding, as required. The erosional impact from seismic shot holes can be reduced by requiring the holes to be adequately plugged. In areas of high hydrostatic pressures, the holes should also be cased. Salt water should be reinjected into the ground in the proper strata (Brockett, et.al., 1971). Salt water that cannot be reinjected should be disposed of on approved disposal sites.

Revegetation should be accomplished rapidly by clearing and constructing drill sites in a planned operation. Revegetation can be accomplished much more quickly if the topsoil in the disturbed areas is removed, stockpiled, and then respread.

The use of a protective or secondary dike around the mud pit and the drill site will reduce the impact of jetted drill cuttings and from accidents by limiting the areal extent of the impacts. The use of proper drilling methods, including drilling with proper mud weight and viscosity, will reduce the loss of drilling fluids or subsurface fluids and the likelihood of their reaching the surface.

The risk of accidents can be reduced by proper drilling methods and safety precautions such as keeping the rig and well location cleared of all debris. Volatile material should be properly stored at all times.

The potential for accidents and blowouts during drill stem tests can also be reduced by running the tests during daylight hours.

The impact from drill stem tests can also be reduced by using steel tanks to retain the produced fluids. Fluids should be removed from the location after the tests have been completed and disposed of under approved methods. (Blockett, et.al., 1971) The impact due to erosion caused when fluids under pressure escape from unsealed strat tests and seismic holes can be reduced by requiring the holes to be sealed with a steel liner which is cemented in place.

As in exploration, the impact on soils due to clearing and construction of roads, trails and well sites during development can be mitigated or reduced to slight or moderate impacts. Pre-planning should limit access to each well to a single minimum width road with no inter-twined trails allowed. The impact due to well drilling and testing can be mitigated as outlined for exploration. Soil disturbance due to construction of dams, tank batteries, pump stations, camps and flow lines can similarly be reduced as prescribed in the above discussion of the exploration stage and the following sections on building sites on steep terrain.

The impact from accidents can be reduced by using all available safety precautions, providing safety and fire equipment, and building protective dikes around any facility where violatile hydro-carbons are stored or treated.

While soil disturbance mitigation measures are similar for the <u>production</u> phase, the increase in magnitude and duration caused by additional wells cannot be mitigated as easily. There will be greater volume of salt water to dispose of.

Rehabilitation measures outlined for preceding phases can be used to mitigate the impact due to construction of the production facilities. Disturbed areas near these facilities will be in continued use and should have a permanent cover to protect the soil from erosive forces. The impacts due to secondary recovery operations can be mitigated as outlined for wells and pipelines for exploration and development.

Erosional impact caused by low water crossings can be reduced by protecting stream crossings with various techniques. Impacts caused by surface disposal of liquid and solid wastes can be prevented or mitigated by following appropriate Federal and State regulations (see Section I. B. and II. A.). Mud pits can be rehabilitated as described under exploration above.

The impact from accidental spills from storage facilities can be mitigated by requiring secondary or protective dikes around the facilities. The potential for leaks and spills from pipelines and flow lines can be reduced under a maintenance schedule system which requires periodic testing of these systems under abnormal pressures. Alternatively, X-ray tests of valves, pumps and lines subject to high corrosion should be run periodically to calibrate remaining effective strength.

Drilling pads, landing strips and minor temporary roads can be ripped, topsoil redistributed, tilled, and drilled with local seed suitable for revegetation upon abandonment.

Stipulations included in the lease, notices of intent and drilling permits should require rehabilitation and revegetation of disturbed areas. Mitigating measures outlined in the exploration phase

above will reduce the impacts due to road, trail, drill site and seismic test sites. Mitigating measures outlined for the development and production phases above will reduce the additional impact from construction of air strips, camps, tank batteries and pipelines. The impact from abandoned wells can be reduced by following the requirements of the U.S. Geological Survey concerning well abandonment. Close supervision during the abandonment phase will prevent further destruction of vegetation by crews dismantling and removing the well pumps and production facilities. Rehabilitation must be verified and accepted by the BLM before surface protection and lease bonds are terminated.

2. Specific

The width of a road may affect mass wasting in addition to causing erosion. To prevent overconstruction of roads the maximum acceptable road width should be identified. Every effort should be made to locate roads where there are no signs of active soil movement or slope instability. Short, steep pitches in road grade can be used when necessary to avoid zones of slope instability. Where a short section of road must traverse an area with signs of instability, plans should include design features which will reduce the potential for mass wasting.

Clues to potential mass movement are summarized as follows: (U.S.D.I., BLM, Preliminary Onshore Oil and Gas Leasing Environmental Statement, Appendix III-A-1, 1972)

Soil Wetness

- Seeps, springs, and other areas where water surfaces.
- Presence of hydrophytes. The hydrophytes must be defined locally.

- Meadows.
- Black soils. These types of soils must be defined locally as having high water tables because many black soils are well drained.
- Soils that are gleyed or mottled.
- Small ponds of water located adjacent to an old slump escarpment (sag ponds).

Soil wetness is very important because water tends to "float" the soil mantle just as a person "floats" in a swimming pool. The soil mantle slides out of a wet area if a road cut removes the support just as water runs out of a swimming pool if a side is removed.

Areas where consolidated bedrock is more than about 10 feet below the soil surface

- Fault Zones - Consolidated bedrock is ground and fractured by the faulting action.
- Pockets of colluvium that have accumulated from previous erosion processes.
- Any type of rock that is composed of hard fragments cemented by a finer grained matrix and the matrix is weathering into clay minerals. (Examples of this situation would be conglomerates, agglomerates, tuffs, and breccias where the matrix has undergone considerable weathering.)

- Areas where the rock has weathered to great depths into soft materials that can be dug with a shovel.

Consolidated, continuous bedrock close to the surface provides a sound foundation to support the soil mantle above an area of disturbance. Fractured, weathered or deep bedrock does not provide support once the area is disturbed. Consequently, the soil mantle slides down the hillside. Cohesionless soils pose the greatest hazard for landsliding on areas described in this category.

<u>Areas where the soil mantle is presently sliding</u>

- Tension cracks. This is where the soil mantle has cracked open as soil moves downhill away from soil that has stayed in place.
- Hummocky hillsides. Usually occurs in plastic soils that are slowly moving downhill.
- "Jackstrawed" or "crazy" trees. Trees tilted at different angles while having a straight trunk denotes very recent soil movement.
- Curved tree butts. The soil mantle has slid during the lifetime of the tree.
- Depressions resulting from the displacement or withdrawal of material downslope.

Present sliding, as denoted by above clues, will be accelerated if the soil mantle is disturbed. Many times clues listed under the first and second categories will be found in conjunction of those listed in the last category.

Precautions to reduce the potential for mass wasting may include, but are not limited to, the following items:

- The road segment should be designed to the minimum width which will safely accommodate traffic and equipment for the intended uses.

- Traffic control devices should be utilized for safety in lieu of wide roads, straighter alignment and sustained grades.

- Road location and design should be such that excavation will not remove support from the base of over-steepened slopes or remove the toe of previous slides.

- Every effort should be made to avoid road locations in steep headwalls of drainages where sidecast of excavated material will increase the potential for mass wasting. If this is not possible, materials should be endhauled to a suitable disposal site.

- Where compaction is desirable, fill material should be compacted to 6 to 12-inch lifts to a uniform density within 95% of maximum as described by the AASHO T-99 at a moisture content as determined to be suitable.

- Perforated pipe should be installed in road ditches where groundwater is contributing to slope instability. Enclose perforated pipe in a gravel filter and cover with gravel and coarse rock

to protect the pipe from road traffic, to help prevent siltation of the pipe, and to support the base of the cut slope.

- Flow and dissipation of energy of water from culvert outfalls should be carefully controlled. Where half-rounds or other conduits are used, they should be bolted to the culvert and firmly staked to the slope. Conduits should discharge water onto rocks or other energy dissipators.

- Roads which will have use over a prolonged period should be surfaced and maintained adequately.

All trails and fire lines should be seeded or mulched, crossditched, or waterbarred before the first winter after construction. Spacings and design of crossditches and waterbars should be adequate to remove water from the trail before it gains enough erosive power to cause rilling. The water should be discharged onto materials or structures which will dissipate its energy and disperse the flow to prevent erosion of the slope below the waterbar.

Building sites on steep terrain can be a source of mass wasting or excess site disturbance if they are incorrectly located or carelessly constructed. To reduce the potential for mass wasting and reduce the loss of site potential from buildings, refineries, transportion facilities, etc., the following precautions should be considered:

- Size, location, and construction of building sites should conform to local ordinances and regulations. Leases should contain stipulations requiring proper compliance.

- Where practicable, topsoil should be stripped from the site and stockpiled for replacement after work has been completed and the area is ready for rehabilitation. Care should be taken to insure locating the stockpile where it will not contribute to or cause mass wasting or additional erosion.

- Topsoil stockples should be seeded, mulched or covered to prevent soil erosion if they are to remain over a winter season.

- Debris left in steep, ephemeral stream channels are often the source of debris slides during winter storms or spring runoff. Debris from construction activities should be removed from these channels promptly.

- Construction methods which leave an over-steepened fill on a slope below a building site create a potential for sliding or slumping. Such conditions should be avoided or preventative measures taken to stabilize the slope.

- Heavily compacted areas may need to be scarified or ripped to a depth of 15 to 18 inches, or to hard bedrock, whichever is shallower prior to revegetation. Stockpiled topsoil should be evenly distributed over the area and graded to a uniform surface prior to seeding.

Oregon's supplement to BLM Manual 7415 - Stabilization (1973), Appendix 3, lists specifications for salvaging and spreading topsoil. Reference for this manual is located under U.S. Department

of Interior, BLM, in Bibliography.

Buildings and structures in refinery areas should be designed to utilize the least amount of soil surface possible. This will lessen the impact of removing ground from the natural state.

D. Water

1. General

Frequent and periodic inspection of all phases of oil and gas activities are necessary to insure that contract stipulations are being followed, that water quality is being protected, and that environmental problems can be detected in early stages and mitigating measures applied. Periodic monitoring of streams for evidence of increased suspended sediment concentrations and the presence of petroleum-related pollutants should be done.

2. Exploration

Adequate planning can reduce the number of stream crossings needed to gather geophysical data on an area. In some cases stream crossing sites should be specified. Crossings should use culverts or bridges designed to carry a reasonable peak flow value, approaches should be constructed to minimize sediment production, and roads leading to the crossing should be surfaced with rock and designed for proper drainage. Fords should only be permitted where the stream bottom is sufficiently rocky not to produce sediment. Approaches to stream fords should be surfaced with rock. Operations should be monitored to assure that Oregon water quality standards are complied with.

3. Development

Drilling permits issued by the U.S. Geological Survey and State of Oregon, and waste discharge permits should require adequate containment or disposal of caustic drilling fluids and brines. Wells

should be cased (all the way to the bottom, if necessary) to prevent contamination of ground water aquifers. Slant drilling and cluster well techniques should be required to protect stream channels and the margins of lakes, marshes, and estuaries. Mud pit and evaporation pond berms should be adequate to contain the contents and anticipated additions due to rainfall.

4. Production

Sewage disposal systems should be designed for the particular soil and ground water conditions at the site.

Production water from wells or separation facilities should be reinjected or contained to prevent contamination of surface waters. Wells, both production and injection, should be adequately cased to prevent contamination of ground water aquifers.

Safety precautions can reduce accidents but some will continue to happen and water quality will be impacted when fires, explosions, blowouts, spills and leaks occur. Holding tanks and other storage areas should be surrounded by impermeable dikes and berms to catch oil when spills occur. These structures reduce the chance of oil getting into and polluting adjacent waters. Timely cleanup of spilled oil should be done to reduce the chance for water pollution. Reinjection of produced water and gas into production formations will reduce the chance of polluting the waters of other formations and aquifers.

Waste disposal systems for refineries should be designed to reduce the concentration of contaminants, including temperature, to a level which is acceptable to the Department of Environmental Quality, State of Oregon.

Abandonment

Proper cleanup, removal and burial of wastes during the abandonment phase will mitigate adverse impacts to water quality. Wells should be sealed and storage tanks and similar structures removed at the time of adandonment. Pipelines should be flushed out and sealed with proper disposal of all residues.

Stream crossings which are no longer needed should be removed. Care should be taken to avoid increasing sediment production.

All sites with exposed soil should be seeded and fertilized to replace protective vegetation.

E. Climate and Air

1. Atmosphere

Preservation of air quality involves all measures which can feasibly be used to eliminate or minimize the introduction of noxious gases, vapors and solid particulates into the atmosphere.

There are laws designed to protect the atmosphere; these provide legal authority for controlling oil and gas operations. Strict enforcement of these laws, regulations and standards can do much to minimize the degradation of air quality by oil and gas operations (see Section I.B. for a discussion of applicable Federal and State laws).

Few effective measures are presently available to reduce the degradation of air quality by the emissions of internal combustion engines used on machinery employed in construction of access roads and drilling sites. The agency administering the operating permit or lease can require that engines be maintained in good running condition, so that excessive amounts of petroleum fuels will not be burned. The operator can also be required to use engines equipped with the most advanced devices for reducing noxious exhausts. There is a fortunate mitigating circumstance, in that most modern construction equipment is diesel-powered and emits lesser volumes of pollutants that would gasoline-powered machinery of comparable performance.

Reduction of dust arising from oil and gas operations can be achieved by several procedural and mechanical measures, all of which are aimed at minimizing soil surface disturbance. Control of access is

the key (USDI, BLM, Preliminary Onshore Oil and Gas Environmental Statement, 1972). These mitigative measures are particularly applicable to the Palouse Prairie Grassland and Cold Desert Sub-biomes, where xeric micro-climates, loose soil surfaces and high wind velocities can create clouds of atmospheric dust.

Where dust hazard warrant extreme mitigative action, road access for exploration might be prohibited, and surface exploration surveys and testing limited to transportation by helicopter or fixed-wing aircraft if landing facilities are available (Ibid.).

If exploration will utilize surface vehicles, road construction may be kept to the minimum adequate for the intensity of the proposed survey or testing. Land Managers should specify optimum locations for proposed roads and drilling sites (Ibid., pp. IV-63, IV-64). Where existing road networks are adequate for proposed exploration, new construction may be prohibited. Limiting road use authorizations to essential vehicles only will also help reduce the dust problem (Ibid.). Dust arising from construction may be reduced by watering of subgrades during excavation and blading operations. Aerial dust from traffic can also be mitigated by periodic watering of roadbeds.

Excessive seismic trail and access road construction can be avoided by cooperative efforts between oil companies (Ibid.).

AND TRUST

Rehabilitation of disturbed soil surfaces should begin immediately after completion of exploration. All roads not needed should be closed. These roads, and unneeded drilling sites, should

be restored to original form and seeded to suitable vegetation (*Ibid.*, p. IV-64).

Some of the same measures used to reduce aerial dust during exploration can be applied as operations progress into the *development* phase; e.g., limiting vehicular traffic to essential needs, minimizing new road construction, and watering to reduce dust. As field activity increases, oiling or surfacing of primary roads with bituminous material or macadam may be desirable. Such treatment will greatly reduce the impact of dust created by traffic.

Where circumstances justify, *development* and *production* operations can be scheduled for periods of favorable weather, when adequate soil moisture and low wind velocities will enable construction and transportation activities to proceed without creating excessive aerial dust (*Ibid.*).

Final rehabilitation of disturbed soil surfaces by restoration to original form and revegetation should be employed as standard abandonment practice for dust abatement (*Ibid*).

Fortunately, atmospheric pollution by blowout emissions is becoming rare during wildcat drilling, development and production operations. In recent years, the oil industry has given much attention to prevention of blowouts during drilling. As a result, in the eleven years 1960 through 1970, only 106 blowouts occurred in the drilling of more than 273,000 wells in eight major oil-producing states (National Petroleum Council, 1971, p. 63). In order to reduce further the rate

of such occurrences, the oil and gas industry and associated service companies have developed training programs to give drilling superintendents, engineers and operating personnel the necessary understanding, skill and practice in well control (Ibid.).

Most blowouts have been from high-pressure gas wells rather than oil wells. In gas well blowouts hydrocarbon vapors, sometimes mixed with hydrogen sulfide vapors, are the principal air contaminants. As a mitigating circumstance, the pollution is usually localized and temporary. Also, since drilling operations are generally conducted in somewhat isolated areas, such contamination normally does not have a significantly harmful effect (Ibid., pp. 63, 64).

If a use or market is available for the natural gases obtained with oil production, the gases should be separated, gathered and transferred to a processing plant, thus reducing air pollution caused by venting or flaring. Some areas have "no-flare" regulations which require that some use be made of the gases, thus mitigating the problem by mandate. Waste oil produced during testing should be transported for recovery or disposed of in some manner other than by burning (e.g., by reinjection into the oil-bearing formation) (Ibid., p. 64).

If flaring, venting of gas or burning of waste oil must be done, degradation of air quality can be reduced by restricting these actions to periods of favorable weather when no atmospheric inversions are anticipated and winds will provide good ventilation.

The occurrence of fires incidental to blowouts can be reduced by measures designed to avoid the cause - the blowout itself. The aforementioned training of drilling personnel is one means of mitigation. Another is the use of a blowout preventer (see Section II. B.). Blowout preventers should be required as standard equipment for all drilling operations. Rigid enforcement of fire safety regulations during drilling will also reduce the incidence of accidental fires.

Evaporation losses of hydrocarbons from storage tanks have not been shown to contribute significantly to air pollution. The industry, motivated by the desire to increase profits, has taken measures to control product losses (National Petroleum Council, 1971, p. 57). Control of emissions from refining operations is a more serious problem (Ibid.).

The major potential refinery emissions which may degrade air quality are sulfur compounds, hydrocarbons, particulates (including smoke, nitrogen oxides, carbon monoxide) and associated odors. Hydrocarbon emissions in the amounts normally released by refining operations are invisible and are considered non-toxic. Various means are used to minimize these releases (Ibid., pp. 69, 73).

The sulfur compounds (hydrogen sulfide, sulfur oxide and sulfur dioxide) continue to cause major air pollution unless available control techniques are used (Ibid., p. 69). Even with controls, there

remain some releases of sulfur oxide and sulfur dioxide which may be significant. New processes now being developed may eliminate most of these residual emissions, (Ibid.).

Various mechanical and chemical measures are available for minimizing the amounts of particulates which are emitted by refinery operations, (Ibid., pp. 69, 70). If these measures are properly applied, refinery emissions of particulates are relatively insignificant.

Odors associated with minor emissions are probably the most perplexing problems associated with refinery operations. Small concentrations well below toxic levels may bring complaints from nearby residents. However, these odorous emissions are usually destroyed by oxidation after a short time in the atmosphere. The increased usage of hydrogen treating instead of chemical treating during refining processes is reducing the nuisance of malodorous aerial compounds. Proper maintenance of refinery equipment can reduce the escape~~ment~~ of odors from leaks (Ibid., p. 70).

2. Micro-Climates

The magnitude of micro-climatic change is directly related to the extent to which man modifies vegetative cover. Thus, the micro-climatic impacts of oil and gas operations can be reduced by preserving as much vegetation as possible during the exploration, development and production phases and, upon abandonment, applying rehabilitation and revegetation measures to disturbed areas (see Section V. F.). Preservation and restoration of vegetative cover will minimize the area of soil

surfaces exposed to direct solar radiation and increased air movement, and will reduce the duration of exposure. By these means, land managers can moderate the effects of soil temperature increased and losses of soil moisture to evaporation on exposed sites.

Permits and leases should include stipulations which, properly enforced, will ensure the preservation and restoration of vegetative cover. The administering agency should employ mitigative measures recommended in Sections V - C, D, and F during <u>exploration</u>, <u>development</u>, and <u>production</u> (USDI, BLM, Preliminary Onshore Oil and Gas Environmental Statement, 1972). Measures considered most important for protection of the micro-climate include:

- Fragile ecosystems needing maximum protection (e.g., portions of the Cold Desert) should be excluded from road access and surface exploration and testing equipment and personnel should be transported by air-craft.
- Existing road systems should be utilized wherever possible.
- Access road construction should be limited to the minimum adequate for the proposed survey or testing. Drilling site area should be limited to actual needs. Overconstruction should be avoided. Road location and construction should be approved by BLM.
- Topsoil removed in leveling drilling sites should be stockpiled for future use.

- Multiple and duplicative exploration operations on the same area should be avoided.
- Revegetation of exposed sites should begin immediately after exploration wherever possible. Unneeded roads and abandoned drilling sites should be closed and seeded to suitable vegetation. Areas exposed by accidental fires should be reseeded or replanted to suitable vegetation as soon as possible. Contamination caused by blowouts or accidental oil spills should be cleaned up as quickly as possible, and the areas revegetated.
- Drilling operations should be monitored to ensure that wells are equipped with blowout preventers which are accessible and operational, each operation is equipped with tools and equipment suitable for the control of fires which may escape into vegetation adjoining the drilling site, crews are organized into teams for suppression of fires which may escape into adjoining vegetation and are familiar with fire tools and equipment, reserve and waste pits are properly constructed to contain drilling muds and formation fluids without breaching or significant leaking, and waste fluids are reinjected into the formations from which they came or otherwise safely disposed of.

The following mitigative measures can be used during the <u>abandonment</u> phase (<u>Ibid</u>.):

- Unneeded roads should be scarified and seeded to suitable vegetation.
- Abandoned drilling sites should be restored as near as possible to original form, scarifying where necessary to relieve soil compaction. Topsoil (which should have been stockpiled when the site was constructed) should be replaced and seeded to suitable vegetation.
- Fluids and contaminated soil from waste pits should be removed and the pits should be leveled and reseeded to suitable vegetation.
- Pipelines, storage tanks, batteries, etc., which might deteriorate and release toxic materials with passage of time, should be removed.

F. Vegetation

1. Terrestrial Vegetation

a. General

The amount of vegetation destroyed by clearing operations, during all phases of oil and gas leasing, can be minimized by limiting the number and dimensions of roads, pipelines, trails, test wells, camp facilities, etc. Only those actually needed to accomplish the job should be constructed; existing facilities should be used whenever possible. Limiting the number of roads and pipelines alone could reduce the amount of vegetation destroyed by 25% to 50%. (Montgomery & McGowan 1971, p. 229).

Another safeguard against excessive vegetation destruction is the prevention or control of erosion which tends to occur following removal of the vegetation. Loss of site productivity by erosion can be mitigated by appropriate controls which in addition to limiting the number and size of facilities, includes (1) designing roads, pipelines, well sites, etc. and employing other practices to insure optimum drainage; techniques include use of perforated pipe (See Sec. Vc., "Soils"), adherence to maximum grades and use of waterbars to slow water flow, insuring that culverts discharge water on non-erosive material, and keeping soil and logging debris out of streams; (2) locating roads, pipelines, well sites, camp facilities, etc., where soils are stable, i.e., avoid areas prone to mass wasting such as the base or midslope of steep slopes, especially headwalls of drainages, or where soils are

exceptionally wet; (3) employing design features to minimize erosion such as end hauling of soil in lieu of sidecasting, assuring that cut and fill slopes lie at the normal angle of repose or less, and using surfacing material to stabilize road surfaces; (4) disposing of end-hauled material in locations not subject to erosion; (5) avoiding construction during periods of heavy rainfall; and (6) revegetating all disturbed areas, including end-hauled material, as soon as possible after disturbance rather than waiting for the abandonment phase (USDI, BLM Preliminary Onshore Oil and Gas Environmental Statement, 1972) (Montgomery & McGowan 1971, p. 229)(Oregon Forest Protective Association 1972, pp. 17-22, 31-34, and 43-47)(Federal Water Pollution Control Administration 1970, pp. 11-21)(Society of American Foresters 1966, pp. 85-107)(Society of American F-resters 1963, pp. 215-252).

It is essential that disturbed areas be revegetated (item 6 above) as opposed to simply seeding or planting. Efforts must, therefore, assure germination and survival of seed or seedlings. Special treatments may be necessary such as top-soil replacement, ripping of compacted soil, fertilization, mulching, watering, and use of special shrub or tree seedlings not normally available.

In general, revegetation of erosion hazard areas should be accomplished initially with fast growing herbaceous vegetation with good soil holding characteristics, and subsequent efforts made to insure early development of native vegetation. (Lute & Chandler 1965, pp. 459-466) (Federal Water Pollution Control Administration 1970, pp. 34-35)(Society of American Foresters 1966, pp. 75-84)(Society of American Foresters 1963, pp. 253-258).

Impacts related to soil compaction are mitigated when numbers and dimensions of roads, pipelines, well sites, etc., are held to the minimum necessary and use or operation of heavy equipment such as tractors, trucks, graders, etc., are confined to planned locations. Compaction on any given area can be minimized by confining operations to the dry season (Thomas 1970, pp. 5, 9). Compacted soils can be rehabilitated by ripping during the dry season and following with appropriate revegetative practices.

Vegetation kills and reduction or loss of site productivity due to contamination by oil or briny water during any or all phases of oil and gas leasing can be mitigated by (1) locating wells, storage facilities, etc., away from drainages, (2) constructing dikes around all facilities that generate or store contaminants; e.g., drilling pads or well sites, mud pits, storage tanks and flow lines, (3) using proper mud weight for drilling and blow-out prevention equipment, (4) using tanks to contain fluids which may flow from wells during drill stem tests, (5) not discharging contaminated water or other toxic material into streams or on the ground surface, (6) re-injecting brine into the ground rather than using evaporation pits, or using only lined evaporation pits of sufficient size to preclude leakage and overflow, (7) development of, and adherence to, contingency plans for controlling blowouts, spills, leaks, etc., (8) installing monitoring systems, including X-ray tests of valves, pumps, etc., to detect and shut down mechanical failures which could result in leaks, spills, or other accidents, (9) casing all wells and test holes where there is a possibility that oil or brine can

mix with aquifers and (10) immediately upon abandonment, seal wells, remove storage tanks and flow lines, and drain mud pits, sumps, etc., and dispose of material in a non-polluting manner (USDI, BLM Preliminary Onshore Oil and Gas Environmental Statement, 1972)(National Petroleum Council 1971, pp. 63-64)(Montgomery & McGowan 1971, pp. 231-232).

Destruction of terrestrial vegetation and site productivity by wildfire can be prevented or reduced by (1) using spark arrestors on tractors and other power equipment, (2) maintaining adequate fire fighting equipment and material such as retardants and water supplies at all operating sites, (3) maintaining adequate communications with State and Federal fire fighting organizations, (4) insuring the availability of adequate numbers of trained fire-fighting personnel, (5) keeping all personnel educated as to the hazards of fire, (6) maintaining fire breaks around fire hazard areas, (7) maintaining constant surveillance of all operating areas during periods of medium to high fire danger, (8) halting all operations during periods of extreme fire danger, and (9) disposing of slash in a manner approved by the BLM which may include scattering of slash accumulations, piling or windrowing of slash, mechanized chopping, or controlled burning, etc. (Where burning is used, it may be limited to conditions of weather that will assure adequate maintenance of air quality) (Oregon Forest Protective Association 1972, pp. 10-12)(Davis 1959, pp. 88-407). Areas disturbed by wildfire should be revegetated as described above.

Impacts of air pollution on vegetation caused by various activities associated with oil and gas leasing are mitigated by (1) actions taken to guard against blowouts (discussed earlier), (2) using

mud as a controlling and circulating medium during drilling instead of natural gas, (3) where practical, utilizing natural gases rather than venting or flaring, (4) disposing of waste oil by re-injection or other non-polluting methods rather than burning, (5) implementation of new control devices, such as smokeless or non-luminous flares for individual well settings where utilization of natural gases is impractical, and (6) implementation of known techniques for removing hydrogen sulfide, sulfur oxides, and hydrocarbons from refinery emissions. (National Petroleum Council 1971, pp. 64, 69, 73). Oil and gas operations must meet State and Federal requirements for protection of air quality (See Section IB and VE).

b. <u>Montane and Northwest Coastal Forest Sub-biomes</u>

Erosion associated with clearing operations in the forested sub-biomes (Northwest Coastal and Montane), where timber harvesting is required, can be mitigated by adhering to practices approved by BLM which may include, (1) avoiding tractor skidding on heavy, wet, clay soils and on steep slopes, (2) locating and building skid trails to avoid sidecasting and steep grades, (3) limiting cable logging to uphill yarding, (4) limiting size of the landing to that necessary to do the job, (5) locating landings on firm ground above the high water level of streams, (6) constructing skid trails and fire trails by providing frequent dips or trail diversions, and (7) stabilizing skid trails by water-barring and revegetating (Oregon Forest Protective Association, 1972, pp. 22-27, 35-39, and 47-52).

In the forested sub-biomes, no revegetation job should be considered complete until all commercial forest land has been reforested

to meet current BLM standards (BLM 5250 and BLM 5700). Development of stands is frequently a complex and difficult task since many factors adverse to tree survival and growth must be controlled; reforestation is most likely to be accomplished by hand planting (Hawley & Smith 1958, pp. 245-258)(Baker 1950, pp. 247-274).

Avoidance of long term impacts through reforestation can be greatly improved by avoiding in the first place, clearing of warm, dry sites (See Section III G 1.) or other areas considered to be "problem reforestation areas" (BLM 5250) where subsequent follow-up treatments are not available to correct specific problems. If "warm-dry" sites cannot be avoided, clearings should be no wider than 50 feet in order to maintain an environment suitable for tree regeneration. (Franklin 1963, p. 7). Early reforestation of commercial forest land may require disposal of logging slash (Hawley & Smith 1958, pp. 275-296) to allow tree planting, treatments to protect trees from animal damage (such treatments are most likely to involve screening of individual trees), and treatments to control competing woody or herbaceous vegetation if tree regeneration is to be established.(Hawley & Smith 1958, p. 246-248). Treatments used to insure establishment of trees should not disturb the site and cause subsequent erosion. Chemical treatments meet this requirement and may be used upon approval by BLM (Oregon State University 1963, pp. 115-147). All treatments should be in accordance with specifications used in BLM land treatment contracts.

Destruction of vegetation in the <u>Northwest Coastal</u> and <u>Montane</u> sub-biomes by insects can be minimized by removing cut or

damaged trees before insects can utilize them for population build-up. (Graham 1952, pp. 139-140). Merchantable material should be sold and removed from the forest; non-merchantable material should be disposed of in a manner approved by BLM. (Oregon Forest Protective Association 1972, pp. 10-12).

Most of the previously described measures for mitigating impacts on terrestrial vegetation, will, if adherred to, mitigate disease damage to Port-Orford cedar. Additional measures recommended, however, to avoid accelerating the spread of the disease include establishing lateral edges of cleared areas at the limits of flow of surface water from the area, not moving equipment from a contaminated area into a clean one and using only clean equipment in uncontaminated areas (steam clean equipment if necessary). The most effective measure, however, is to avoid entry of people, animals, and equipment in stands containing cedar of any age (Roth, Byrum & Nelson 1972, pp. 4-5).

2. <u>Aquatic Vegetation</u>

Mitigating measures to prevent soil erosion, degradation of water quality, loss of water supplies, destruction of terrestrial vegetation and destruction of aquatic wildlife also apply to mitigation of harmful impacts of oil and gas operations on aquatic vegetation. For this reason, only the most important mitigating measures pertaining to aquatic vegetation will be discussed in this section. (See Sections V -- C, D, F.1., and G.2.)

During the <u>exploration</u> and <u>development</u> phases, roads, pipelines and other facilities can be located to minimize the destruction of aquatic vegetation at stream crossings and to avoid disturbance to aquatic habitats of significance. This can be accomplished by stipulations in leases and notice of intent before intensive <u>exploration</u> begins and in leases and permits before <u>development</u> commences (USDI, BLM, Preliminary Onshore Oil and Gas Environmental Statement, 1972).

Mitigating measures to reduce the number of landslides that originate from roads constructed during the <u>exploration</u>, <u>development</u> and <u>production</u> phases are discussed in detail in the section on Aquatic Wildlife (Section V -- G.2.). These practices will not be reviewed again here. Erosion caused by oil and gas operations during all phases is reduced by limiting surface exploration and access construction to dry months, requiring proper road and pipeline locations, construction, drainage, seeding, mulching, water bars and surfacing, using protective dikes around mud pits, exploratory wells, storage tanks, batteries, and

evaporation pits, using proper drilling techniques, safety precautions and maintenance schedules while drilling wells, and stabilizing disturbed soil at stream crossings, channel changes or gravel removal operations in stream channels, and steep cut banks near streams.

Loss of ground water from shallow aquifers can be minimized by casing the wells.

Mitigation of blowouts may be accomplished by the use of blowout preventors, good safety and maintenance procedures, locating drilling sites away from surface waters, constructing dikes around drilling sites, using contingency plans to cover adverse impacts from blowouts, and keeping necessary equipment on hand to clean up impacted waters as soon as possible after a blowout. Equipment to suppress fires started during blowouts, as well as from explosions or other accidents, should be readily available.

Impacts of oil in aquatic vegetation from sources other than blowouts can be minimized during exploration, development, and production by installing monitoring systems in pipelines to detect and shut down mechanical failures, e.g., line-pressure sensors and block valves (National Petroleum Council, p. 71) constructing berms around storage batteries, tanks and separators, giving protective coatings and cathodic treatment to prevent corrosion of pipes, insuring that evaporation pits are of sufficient size and constructed of impervious materials, reinjecting waste oils and unseparated hydrocarbons

into the production formation, and adequately capping wells during <u>abandonment</u> to prevent oil from escaping into subsurface and surface water supplies.

Reliable methods for collecting oil after it has entered streams have not been developed. Floating booms can be used to contain and collect some of the oil that gets into ponds or lakes. Straw is the best material to use along shores of lakes to collect spilled oil. (Montgomery and McGowan, p. 232.)

Mitigative efforts to keep saline water and other toxic materials from killing aquatic vegetation include adequate well casing, preventing well blowouts, locating wells away from streams or lakes, proper containment and reinjection of briny water into producing formations, proper construction and size of evaporation pits, and adequate sealing of wells during <u>abandonment</u>. Pipelines, storage tanks and separators should be routinely checked to prevent leaks. Secondary dikes should be built around wildcat and production wells to prevent toxic substances in drilling mud from reaching streams or lakes.

Oil spills at marine terminals and refineries can be partially mitigated by special equipment and exercising caution. Oil spillage during cargo transfers can be minimized by use of loading control facilities on tankers. Terminal pipelines should be properly coated to prevent leaks. Periodic inspections and testing of lines and storage tanks should be done. Block valves and automatic shutdown equipment should be used to reduce oil loss when leaks occur. Oil

losses from transportation pipelines can be mitigated by having them placed aboveground, conducting frequent inspections, giving them special protective coatings, and installing block and shutdown valves at frequent intervals.

Improved weather forecasts, better navigational aids, improved shipping lanes, and strict traffic control in crowded areas would help prevent tanker accidents at sea. An adequate ballast water treatment plant should be built at the terminal. On-board separators or holding tanks could be installed on tankers to temporarily store ballast water until reaching the terminal.

Ocean oil spills can not be successfully contained in moderate or heavy seas. Floating booms can partially contain and allow mechanical recovery of some spilled oil in protected harbors and estuaries. Spraying oil slicks with selective bacteria which digest and breakdown crude oil is being tried and offers promise. Straw can be used to collect oil on shorelines.

Methods for disposal of refinery chemicals include regeneration, air oxidation and neutralization and injection into special waste disposal wells. Some chemicals may be sold for other industrial uses.

Waste water should be treated by stripping or oxidation to remove dissolved pollutants before discharge from the refinery. Organic components in waste waters can be removed by biological oxidation.

Trickling filters and activated-sludge treatment can also be used to remove organic impurities and dissolved and suspended matter. These methods help mitigate adverse effects on vegetation.

Sludges containing oil, water, and solids should be settled in ponds, or dewatered by vacuum filtration or centrifugation (National Petroleum Council, p. 67). The solid wastes should then be disposed of in a fashion that will not contribute to water pollution.

Effluent monitoring should be conducted to be sure treatment processes are working properly. Periodic monitoring of vegetation in the receiving water should verify the results of effluent monitoring.

G. Animals

1. Terrestrial Wildlife

Mitigative measures recommended for reducing or eliminating impacts on wildlife are applicable to all of the sub-biomes in Oregon.

Prior to issuing oil and gas leases and permits for exploration, crucial wildlife habitat areas, including wintering, breeding, nesting, fawning, calving and kidding grounds and migration routes, should be identified. These areas can be covered with protective stipulations or excluded from oil and gas exploration and leasing.

Aerial and seismic exploration activity should be timed to avoid wildlife areas during critical times. Well heads can be located away from important habitat areas and wells drilled on a slant to explore or tap pools located beneath them (Shell Petroleum, 1966). Exploration impacts can be further reduced by joint use of one contractor to conduct aerial or seismic exploration for several companies. The number of trails, roads, drill sites and other surface disturbing activities could be reduced in this manner. Both the Federal Aviation Administration and the State Game Commission can establish minimum aircraft flight elevations over waterfowl refuges and other critical wildlife areas (USDI, BLM Preliminary Onshore Oil and Gas Environmental Statement, 1972).

During exploratory and production drilling, drilling water and mud can be kept out of wildlife water supplies by storing them in metal tanks or leakproof pits. Briny water resulting from producing

wells should be re-injected into the ground (See Figure 5, Section II). Mud pits located near waterfowl habitat should be covered to prevent waterfowl entering and becoming entrapped in them. Fences should be built around mud pits where there is danger of large animals falling into them.

Waste by-products from drilling and refining can be prevented from entering wildlife habitat with proper storage, treatment and disposal methods.

During development and production phases, oil storage and refining facilities should be kept away from critical wildlife habitat areas. Power lines located on or near heavily used flyways should be placed underground. Safety devices, to prevent electrocution of perching birds, should be installed on power poles and cross arms. Utility poles located near busy roads should be designed to prevent raptors from perching on them.

Pipelines placed above ground should be designed to prevent interference with migratory habits of wildlife. Above ground installation of pipelines would provide easier detection of leaks, reducing the hazard to wildlife habitat from oil spills (Ibid).

Temporary construction camps and permanent field operation facilities can be located away from crucial wildlife habitat. Compliance with State and Federal air and water quality and solid waste standards should prevent or minimize impacts on wildlife associated with these facilities. Refining wastes can be recycled by adding them to fuel oil

used for refinery power generation, or stored in leak-proof tanks pending ultimate disposal in conformance with Federal, State and local regulations (Petroleum Council, Vol. 2, pp. 162-172).

Reclamation of abandoned drilling sites and producing fields should include revegetation of disturbed areas with plant and grass species beneficial to wildlife. Open pits should be filled in and revegetated as well.

2. <u>Aquatic Wildlife</u>

The most serious impacts of oil and gas operations on aquatic resources are the result of excessive sedimentation, accidental blowouts of wells, spills and leaks of oil and gas, briny water, and caustic components of drilling, contamination of ground water, and physical alterations to the aquatic habitat. Measures to mitigate these and other lesser impacts generally apply to all sub-biomes. Many of these measures are intended primarily to protect soil and water quality, but these efforts are also of utmost importance in maintaining satisfactory habitat conditions for all aquatic life.

Mitigating measures to reduce soil erosion discussed in Section V c of this report help alleviate the harmful effects of sediment on aquatic life and habitat.

Some of the more important mitigating measures dealing with road construction include:

- Utilizing resource specialists (hydrologist, soil scientist, soils engineer, etc.) to help plan road locations, construction sites, identify fragile areas and other important resource areas.
- Excluding critical aquatic habitat areas from all surface activities locating wells away from steep slopes or fragile soils, utilizing existing roads and trails, and construction roads to BLM standards.
- To reduce the chances of earth slides entering streams, roads should be carefully located to avoid unstable areas.

Steep slopes should not be overloaded with sidecast. Special construction practices such as end hauling, fill compaction and extra drainage should be used when crossing unstable areas. Culverts large enough to pass flows during major floods should be properly installed. Fill slopes should be protected from culvert outfall. Road cuts and fills should be stabilized before winter rains or spring runoff by vegetation or other means. Culverts should be maintained and cleaned to prevent plugging during and after heavy rainfall or snow-melt. Denuded stream banks should be replanted with grasses, forbs and shrubs. Where stream beds have been scoured, structures can be installed upstream to create pools (gabions, log and board dams or trash catchers), and spawning gravel can be placed in the streambed in the pools above the structures.

- Material should not be removed from stream channels unless a permit is obtained by the permittee or lessee from the appropriate State agency, and a satisfactory plan to protect aquatic life and prevent siltation while removing the material has been approved.
- Streams should not be channeled or relocated unless it is absolutely necessary to do so. In any case, advice and concurrence from the State of Oregon should be obtained beforehand.

- Road culverts should be designed and installed to allow fish passage for both anadromous and resident species.

Prevention of all accidents that result in oil pollution and harmful effects on aquatic wildlife is improbable, but their frequency and magnitude can be reduced by careful operation of drilling equipment and good maintenance procedures to prevent fires and explosions. Well blowouts can be reduced by the use of blowout preventors. Since it is most important from the standpoint of aquatic live to prevent oil from getting into streams or lakes, slant drilling could be required at specific sites to keep drilling operations further away from surface waters. In especially sensitive areas, secondary dikes can be constructed around the drilling site to contain oil in case of blowouts and during setting of drill cuttings. These measures can also alleviate increases in surface water temperatures.

Saline water contamination of streams and other surface waters can be reduced by locating drilling sites away from surface waters, using tanks to contain any liquids that flow from the well during drill stem testing, preventing blowouts during exploration and development - using blowout preventors, good safety practices, and recommended drilling techniques and casing the wells.

Mitigation to keep drilling muds from contaminating streams and lakes include construction of secondary dikes around mud pits using blowout preventors, and disposing of drilling muds where they will not degrade the environment.

Pollutants should be kept from ground water. Freshwater should be protected from oily or briny water from deeper strata by sealing off the freshwater zone with cement plugs around the well casing.

Consumption of water during drilling can be reduced by casing wells in highly permeable areas.

Careful planning of roads, pipelines, separators, and storage batteries during development of an oil field would eliminate unnecessary roads and reduce soil disturbance. Stream crossings should be carefully planned and executed to reduce soil erosion. Fills can be ripraped, banks seeded, and cuts stabilized.

Mitigative measures to reduce sedimentation and water pollution from oil, saline water and drilling mud discussed above. Also apply during the development phase (See also Sections V C, D and F).

During production the following measures minimize the chances of oil getting into surface waters and destroying aquatic fauna. Blowout preventors reduce the chance of blowouts during drilling of production and water injection wells. Fires and explosions can be reduced by good safety practices and maintenance procedures. Leaks and spills from gathering systems and other pipelines can be minimized by following maintenance schedules that include periodic inspection and testing, use of pipes given protection from corrosion and using block valves, line-pressure sensors and automatic shutdown equipment (National Petroleum Council, p. 71).

Secondary or protective dikes (berms) should also be constructed around storage facilities and holding tanks to catch oil when spills or accidents occur. Waste products can be reinjected into the production

formation or disposed of in a manner acceptable to State and Federal authorities.

Quick remedial action can sometimes prevent oil spills from getting into surface waters. Emergency cleanup equipment should be available near the operations. See Section V F 2 for additional measures for cleaning oil spills from surface waters. The use of detergents and other chemicals to disperse oil slicks is not recommended because of the potential for greater damage to aquatic organisms (Montgomery and McGowan, p. 232; Water Quality Criteria, p. 72; and National Petroleum Council, p. 77).

Saline water should be properly contained and reinjected into producing formations or salt-water producing zones during production (National Petroleum Council, p. 63). Briny water should be treated before release on land if water averages more than 500 ppm. of hydrocarbons, 1,000 ppm. dissolved solids, or 100 ppm. of hydrocarbons (Montgomery and McGowan, p. 231). Evaporation pits should be well constructed of impervious material, be of adequate size to hold the expected volume of water, including rainfall, and be located away from natural drainages. Pipelines, storage tanks and separators should be checked periodically to prevent leaks.

Immediate reinjection of production water would reduce loss by evaporation, minimizing the amount of supplemental water needed during secondary recovery operations. Care must be taken while reinjecting production water into production formations to keep saline water from contaminating aquifers.

Because of climatic conditions, topography, limited sources of surface water and low annual recharge, impacts on aquatic organisms are most critical in the Cold Desert. Mitigation of impacts should be carefully followed to protect aquatic species and their habitat. Actions intended to protect aquatic resources are similar to those discussed above, but should be followed to a greater degree. Small ponds or lakes should not be drawn down to critical levels during development and production phases of oil and gas operations. Habitat for rare or endangered fish should be identified and excluded from leases, or protected by special lease stipulations, prior to issuing oil and gas leases or exploratory permits.

Problems of mitigation in the intertidal and marine waters of the Northwest Coastal Forest are somewhat different than elsewhere. Spillage of oil during cargo transfer and storage at marine terminals could be partially mitigated by following procedures discussed above for preventing and controlling leaks in pipelines and tank batteries. Tankers should be equipped with loading control facilities that minimize the chance of spills occuring during loading and unloading.

If marine terminals or refineries are built in Oregon, a well-staffed and well-equipped oil spill control center should be established (National Petroleum Council, p. 21).

Major oil spills from tankers could be partially mitigated by improved weather forecasts, better navigational aids, improved shipping lanes, and strict navigation and traffic control in crowded waters. Instead of discharging oil-contaminated ballast water on the high seas, on-board separators or holding tanks should be used to

temporarily hold these wastes. Disposal facilities for oily ballast and other wastes should be constructed at the terminal or other suitable location.

Oil spills cannot be contained or removed in heavy seas (wave heights exceeding 3 feet or surface currents in excess of 1 knot). Some containment and mechanical recovery is possible by floating booms in protected harbors and calm inland waters. Use of selective bacteria, applied by aerial spraying, to break down and digest crude oil slicks has been successful in experiments. To date straw has been used with the most success to collect oil at sea and on beaches.

Methods to reduce crude oil pollution of estuaries and intertidal areas resulting from leaks in transportation pipelines (to marine terminal or refinery) are similar to those discussed above for terminals and oil fields.

Waste products from oil refineries should be kept out of aquatic habitat by adequate collection and drainage systems designed to collect and hold waste materials (Ibid., p. 67). Oil-water separators can be used to separate and recover oil from refinery waste. Flocculation and air flotation can also be used to remove oil and suspended solids from refinery waste.

Waste water containing dissolved pollutants from refining can be treated by stripping or oxidation. Biological oxidation removes organic components in waste waters, while trickling filters and activated-sludge treatment can be used to remove dissolved and suspended matter and organic impurities.

Sludges containing oil, water, and solids present the most difficult disposal problems (Ibid., p. 68). Centrifugation and vacuum filtration are used to de-water sludges that settle out in special ponds. Sanitary land fills are commonly used for disposal of sludge wastes.

Continual monitoring of refinery effluent is essential to be certain treatment processes are working properly, and that harmful substances are not being released into receiving waters. Stream or estuary monitoring should be done to substantiate results of effluent analyses.

Use of a diffusion mechanism, where natural currents are absent, for mixing or dissipating effluents in receiving waters can eliminate undesirable concentrations of effluent in localized areas.

Upon abandonment, wells should be sealed as required by U.S. Geological Survey procedures (See Section II A) and State of Oregon regulations. Pipelines and storage tanks should be drained and flushed or removed, and mud and evaporation pits drained and rehabilitated.

3. Domestic Livestock

Measures recommended for mitigating impacts on domestic livestock due to land taken out of production are virtually the same as those prescribed for the mitigation of impacts on terrestrial and aquatic vegetation. Proper planning of exploration access routes, seismic testing lines, roads, location of drilling pads, and other facilities and structures can reduce the size of areas disturbed and the amount of vegetation destroyed. Agencies involved in the management of land surfaces must assist in planning for the proper location of roads, drill site pads and other structures in order to minimize surface disturbance.

The location and width of roads and seismic testing lines should be kept to the minimum needed for required equipment. Whenever possible existing routes should be used. Surface exploration methods other than the construction of seismic lines should be considered, particularly in fragile areas. Adequate pre-planning will limit access required for each well during the development phase, as well as reduce the amount of disturbance caused by the construction of pipelines, electric lines and other facilities.

Controlling access is a primary factor in minimizing disturbance to livestock. After necessary work is carried out roads should be closed and rehabilitated to eliminate long term affects of indiscriminate use by the general public. Surface exploration access

construction and other activities should be coordinated with domestic livestock use whenever possible. Some grazing management practices require that livestock use designated areas only during a specified time. Many oil and gas exploration and construction activities can be accomplished when domestic livestock are not grazing in adjacent or surrounding areas.

Aboveground pipelines, tanks, pumping stations and air strips may physically restrict livestock movement. With proper grazing and construction planning, the location of these facilities could assist in manipulating grazing animals to benefit vegetation and related resources and the livestock themselves. If the area is under intensive grazing management at the time field development activities commence and the physical barrier of installations is significant, construction should be modified to avoid or mitigate problems. An example would be to bury aboveground pipelines at intervals that would allow passage by livestock.

Although noise may not have significant adverse effects on domestic livestock, it can be reduced through proper muffling of engines and by housing flowline pumps.

The frequency and magnitude of accidents such as spills, leaks and fires can be reduced by careful attention to equipment, operations and maintenance, and using skilled equipment operators. Safety precautions, including the use of safety and fire equipment, and enclosing

oil storage and treatment facilities with protective dikes and fences should be followed.

Leaks and spills from pipelines and flowlines can be reduced, under a maintenance schedule system, by requiring periodic testing under abnormal pressures. In addition, X-ray tests of valves, pumps, and lines subject to high corrosion should be run periodically to determine their remaining effective life. Blowouts that destroy vegetation can be reduced by running drill stem tests only during daylight hours. The impact from drill stem tests can also be reduced by requiring the operator to use steel tanks to retain waste fluids.

Prompt removal of livestock from areas where accidental contamination of water or vegetation occurs can minimize toxic effects.

Blowouts, spills or leaks should be cleaned up as quickly as possible. Oil residues that cannot be removed should be buried or mixed into the soil in designated areas where they can decompose organically. Vegetation destroyed due to blowouts or contaminated water should be replaced after proper cleanup and removal of wastes.

Immediately after completion of exploration and abandonment phases, rehabilitation and revegetation measures should be undertaken as required by stipulations contained in the leases and drilling permits. Disturbed areas should be revegetated utilizing whatever rehabilitation measures are necessary to assure a high probability of success. Exploration access routes and seismic testing lines should be tilled and seeded with vegetation species that stabilize the soil

and provide forage for livestock. Disturbed areas caused by construction of pipelines, electric lines and other facilities should be revegetated shortly after the areas are disturbed. In the <u>development</u> phase land areas which have been subjected to contamination or disturbance should be revegetated as soon as possible using whatever rehabilitation measures are necessary.

Upon <u>abandonment</u>, drilling pads, landing strips and minor temporary roads can be ripped, tilled and revegetated. Surface and subsurface materials injurious to plant growth should be removed below the root influence zone. Rehabilitation measures such as scarifying, seeding and mulching should be carried out as necessary. Most revegetation can be accomplished rapidly if the top soil is first removed, stockpiled and later respread.

Protective and rehabilitative measures should be taken as necessary to insure that potentially dangerous holes, sump pits, etc., are plugged, covered or filled.

H. Micro- and Macro-Organisms

1. Soil Organisms

Proper use, handling, and storage of chemicals during all phases of oil and gas operations can minimize spillage which harms soil organisms. Populations of soil organisms may be enhanced during abandonment phase by tilling compacted soil, adding organic materials, and seeding to protect the soil from erosion. Areas which were covered with concrete or asphalt for a number of years may be inoculated with organisms by spreading manure over the area, tilling it into the soil, and seeding to appropriate vegetative species. The same technique may be utilized on mud pits and areas exposed to spillage of various substances.

All actions described under Section V -- C (Migigating measures, soils) are applicable to protecting soil organisms.

2. <u>Aquatic Organisms</u>

Mitigating measures described in Section D (Water) should be applied here. In addition, intensive monitoring of aquatic communities will be necessary to assess environmental impacts; in fact, it will be necessary to conduct initial surveys of aquatic communities to establish what species are present in order to detect changes in composition of these populations.

Surveys and monitoring of aquatic communities should be done by experienced biologists who will be able to evaluate the significance of population changes. For example, certain common species of aquatic insects are susceptible to the effects of pollution by organic wastes, while other species are extremely tolerant. The elimination of sensitive species and the increase in the population of tolerant species may be used to indicate the presence of organic pollutants (E.P.A., The Practice of Water Pollution Biology, pages 12-17). It may be possible to utilize other sensitive-tolerant species groups to indicate the presence of petroleum-related pollutants. It is possible that close monitoring of the dynamics of aquatic communities could provide a reliable method for evaluation of environmental damage.

I. Social, Economic, and Land Use

1. Health and Safety

a. Industrial Personnel

Industry, government, and insurance companies need to continue to work together to identify safety problems and develop procedures, equipment, and training to reduce safety-related problems.

b. General Public

Controlling access to dangerous areas would be the best way to reduce or eliminate hazards to the general public. Fencing around critical areas and operations and production facilities should be done. Abandoned air strips should be marked with X's on each runway to denote their closure or they should be obliterated and the site rehabilitated.

Public use areas should be clearly marked with signs pointing out hazardous conditions.

2. Social-Economic Factors

Many of the impacts of oil and gas activities cannot be dealt with on a site-by-site basis, but must be treated on a regional or state-wide level.

Mitigation depends to a large extent on the early development of comprehensive land use plans and adoption of appropriate local land use controls. Desirable long-term development goals should be formulated by Federal, State and local entities. Goal formulation

and planning must include active participation by the public. Social, economic, and natural resource values can be identified. Plans, including alternatives, can then be formulated based on resource capabilities and goal objectives. Conflicts between oil and gas development and other land uses can be identified early enough to develop measures to reduce or eliminate them.

a. <u>Exploration and Development of O&G Fields</u>

Many adverse impacts are caused by extremely fast development after discovery is made. Secrecy in the industry and uncertainty over legal rights can cause an "Oklahoma land rush" when a discovery is made. Exploration and confirmation of oil and gas deposits by an appropriate governmental agency would largely eliminate the "land rush" aspect. Rights to acquire and develop new discoveries could be sold to the highest bidder.

b. <u>Revenue Sharing</u>

The oil and gas resource is depletable and finite. In rural, economically depressed areas having little industry, extraction of oil and gas resources for use in more industrialized regions can leave little economic benefit to the local region.

Implementation of severence or depletion taxes by local governments can give them a share of the economic benefits and ease the eventual letdown as production tapers and abandonment occurs.

3. <u>Land Use Factors</u>

Land use conflicts can best be resolved by comprehensive local and regional land use planning and the adoption of effective land

use controls before leasing and exploration take place. Land uses such as wilderness, intensive recreation, and urban residential development, which are basically incompatible with oil and gas operations, can be protected by stipulations in leases, or by excluding areas where these uses occur from leasing.

Land uses such as agriculture, livestock grazing and industrial forest management, can co-exist reasonably well with oil and gas operations. Impacts on these land uses can be mitigated by use of erosion control, revegetation, and water quality protection measures previously discussed. These uses, too, will benefit from stipulations that restrict oil and gas operations in areas critical to these uses.

Provision for the use of oil and gas access roads for other mineral exploration would facilitate prospecting for and development of other mineral resources in areas now devoid of roads. Multiple use of these roads could preclude the need for construction of additional roads.

Plugging of abandoned wells would prevent the detrimental effects of corrosive brines and poisonous and explosive gases and liquids on other mineral operations in or near abandoned fields.

Unlike the mitigation measures generally prescribed for abandonment, however, the partial or complete eradication of the roads, trails, air strips, camps, and electrical transmission lines could have a detrimental impact on mineral operations in the general area. These facilities could represent a positive asset to development of other minerals.

J. **Aesthetics and Human Interest Values**

1. **Aesthetics**

There are a number of mitigating measures which can be taken to reduce the visual impact of exploration. These include:

- Limiting access to existing roads and trails. If additional clearing is needed, it should be limited to that necessary to get the equipment to the site. Clearing dozer trails to bare soil should be prohibited.
- Access roads for subsurface exploration should conform to the landscape as much as possible, follow contours, have adequate drainage and erosion controls.
- Drill sites and pads should be kept to minimum size.
- Retaining dikes should be built around mud pits and sumps.
- Drill sites should be located in areas which are as inconspicuous as possible, hidden from heavily traveled roads, below skylines wherever possible and not on steep slopes which would require large excavation to make a level pad.

Much of the maze of roads, seismic lines, pipelines and powerlines associated with field development could be reduced by careful pre-planning. Careful attention to the location of roads, pipelines, and powerlines, as well as good design standards, would eliminate much of the visual impact. Careful location of tank batteries, pump stations, and other surface structures can alleviate the visual problem. Immediate revegetation of all exposed soil on cut and fill slopes would reduce the impact of surface scars. The use of natural blending colors for surface structures would make the facilities less obvious from a distance.

Little additional visual impact occurs in the production stage. The same considerations that were outlined under development above should be applied to additional pipelines, pump stations and treatment facilities developed. Most of the noise and odor problems associated with production can be controlled through proper mufflers on the engines, housing of flowline pumps and control of the produced oil and gases.

Odors associated with refinery processes are usually destroyed by oxidation after a short time in the atmosphere. Use of hydrogen treating instead of chemical treating simplifies the problems of malodorous compounds. Good maintenance practices will aid in controlling odors emitted from leaking equipment. Noise levels associated with refineries can be abated by the following measures:

- Careful design and use of special equipment to avoid turbulence and vibration in movement of fluids.
- Limiting velocity and providing silences and noise shields for atmospheric vents.
- Locating higher noise sources away from communities or shielding them by other facilities.

Visual impacts in many areas can be largely eliminated in the abandonment phase by removing all surface structures and regrading well pads, roads and impoundments to as near the original surface as possible, then replanting with native vegetation.

2. **Geological Values (Human Interest)**

Areas of exceptionally high geological value and fragility should be excluded from oil and gas leasing or protected with lease

stipulations. The range in types and variation of geological phenomenon make it difficult to make general statements, but individual features on a small scale should be handled similar to archeological or historical sites.

Most impacts on geological features can be mitigated by keeping actions at a distance from the feature. Areas of high fossil value or other removable features that are deemed valuable either scientifically or for sightseeing should be signed and fenced or removed under scientific supervision to prevent vandalism. The Antiquities Act of 1906 should be enforced. Briefing and education of oil and gas crews to specific geologic values where these are known to exist, can prevent damage to fossils and unique geologic features by unaware operators. Significant resources can be identified through various Federal and State agency inventories, through local contacts and by geologists associated with the oil and gas endeavors. This information should be given to oil and gas companies and their sub-contractors.

Where operations take place in areas of geological value, planning should insure that damage is minimized, particularly in earth moving and restoration. Slant drilling and camouflaged well setups can alleviate many aesthetic impacts in these areas. Reclamation after abandonment should restore these areas to as near original condition as possible.

3. <u>Archeological Values</u>

The best measures to protect archeological values are to avoid disturbing them, or salvage excavate them before they are disturbed.

Where archeological sites are known, they can be excluded from leases, or protected by stipulations in the lease. Where this is not possible, or where values are suspected to exist but their locations are not known, archeologists should survey operational areas in advance. Sites in the path of operation can be evaluated and, if valuable, marked for protection or salvage excavation. Operations that uncover unknown sites should ease while an archeological determination of the value of the find can be made, and salvage undertaken if warranted. The quantity and variety of archeological sites in desert areas, and the amount of destruction that has taken place in the past, necessitates the use of an archeologist in almost all phases of oil and gas operations. Springs often are rich archeological sites and should be avoided in development unless they can be salvaged or monitored by an archeologist.

Thumpers, vibrators and explosives used in <u>exploration</u> should not be used close to archeological sites. Earth moving equipment should not be operated close to fragile sites marked for protection. Vehicles and equipment should be restricted to existing roads and trails in areas of high archeological value.

Fluids used in operations should be kept away from archeological sites, or contained in leak-proof containers and surrounded by protective dikes. Diversion ditches to drain escaping fluids away from the sites would provide additional protection.

Educational briefings to company employees can foster an awareness of archeological values and how to recognize and protect them. Areas having high visitor use should be protected by signs, special trails for foot use only, and monitored to prevent vandalism.

4. <u>Historical Values</u>

Historic trails should not be used for vehicular traffic of any kind. Such use should be relegated to roads off and away from the historic trails. Development and production activities, such as construction of drill pads, roads, reservoirs, etc., should not take place near historic sites or structures. Areas having high historic value should be identified in pre-lease evaluations and precluded from leasing, or protected by special lease stipulations.

Thumpers and vibrators should be used, rather than seismic explosives, where it is necessary to conduct surface <u>exploration</u> in or near areas with historic structures and sites. Where it is essential that blasting must be done near fragile historic structures, shoring and bracing should be used, and windows removed or covered. Packing and padding should also be used to prevent damage.

Where caustic liquids or gaseous wastes may affect historic structures, measures should be taken to counteract their effects. Preservatives such as hydrozo or pencapsula can be used to prevent deterioration. Where finishes have been affected, they should be reconditioned in a manner in keeping with the historic aspect of the structure.

Fire damage can be prevented by constructing fire lanes by precautionary measures such as fire around historic sites, and having fire suppression equipment available.

As with archeological values, educational measures to mitigate the effect of intorducing people into an historical area should be made. Employees should be alerted to the values involved and why and how they are to be protected from damage. This can be done with literature, interpretive signs, and training sessions.

5. <u>Cultural, Ethnic and Religious Values</u>

Mitigation of impacts on cultural, ethnic and religious groups can best be done through good community relations. Education of company employees to local customs, religions and life styles can go far towards preventing conflicts. Positive efforts to invite local participation in company operations, i.e., jobs, meetings, etc., should be taken. Special efforts to protect sites used in cultural and religious ceremonies should be taken and any damage promptly repaired.

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VI. Adverse Impacts that Cannot be Avoided Despite Mitigation

This section discusses the impacts that can be expected to remain despite application of mitigating measures presented in Section V. Included are unavoidable impacts not subject to mitigation and the net remaining adverse effects of impacts partially mitigable.

This section is necessarily subjective to a degree, in that a judgmental factor must be imposed to estimate the effectiveness of mitigative measures presented in the previous section. It is assumed that prescribed mitigation procedures presented therein will be diligently applied.

A. Ecological Interrelationships

Any human action that alters the abiotic environment or biotic community can impair ecological relationships to some degree; mitigative measures cannot be entirely effective. Despite all feasible precautions, some oil and gas operations will upset the natural balance of ecosystems at least temporarily. Actions or accidents which destroy vegetation, disturb soil, degrade water quality and pollute the air will cause some disruption of ecological interrelationships. In these instances the nutrient cycle and hydrologic cycle may be interrupted until the affected area is revegetated and soil is stabilized, or until the source of pollution is removed.

Fragile ecosystems, where productivity is low and the natural balance delicate, will be most severely impacted and slowest to recover, particularly where the ecological equilibrium has been impaired by other human activity prior to oil and gas operations. If grazing, road construction, logging, minimg, recreation, etc., have already affected ecological interrelationships, the added impact of oil and gas operations may create a total cumulative effect that may not be offset by mitigative measures.

Unavoidable impacts on the individual environmental components are discussed in the following parts. Many of these will have direct or indirect effects on ecological interrelationships.

B. Physiography, Geology and Minerals

Some subsidence of the land surface and contamination of groundwaters may result despite mitigative measures.

There will be unavoidable impacts on other mineral resources within the productive limits of an oil or gas field due to the physical occupancy of installations and roadways.

C. Soils

In all sub-biomes, whenever the natural interactions of parent material, vegetation, topography and climate are disrupted by any action, the soils will be affected. Mitigating measures do not restore soils to their natural state. They may be protected and managed but some degree of impact will remain until natural interactions have time to reach harmony with each other.

Erosion processes are accelerated any time the protective cover is removed and the soil is disturbed. Mitigating measures can reduce erosion but do not eliminate it. Productivity of the natural vegetation will be reduced if the area is disturbed or compacted. Some fill or cut bank failures will occur when roads, trails or building sites are constructed on very steep terrain. Accidents will always occur. They may range from no impacts on the soil to soil sterilization. Areas where drilling mud is expelled, drilling fluids are stored, or where brackish water or oil are sprayed will not recover to their initial state.

Permanent road systems and building sites essentially eliminate the natural soils. Liquid and solid waste disposal sites will show some degree of deterioration despite mitigation.

D. Water

Stream crossings will inevitably produce suspended sediment. The act of constructing adequate stream crossing structures and fords will increase suspended sediment during the construction phase. Unexpected, or unusual, peak flows may cause stream crossing structures to fail. These climatic events may also cause mud pits to overflow and the contents to enter stream channels. Failure of earthworks which contain production water during heavy rains may allow brine and oil to reach streams, lakes, and marshes.

Geophysical data may be misinterpreted and shallow, or narrow, ground water aquifers may be overlooked and not cased to prevent contamination by production waters. Well casings for both production and injection wells may leak and allow contaminants to reach ground water aquifers.

E. Climate and Air

Even with good cooperation by the oil and gas industry, application of all feasible mitigative measures and careful observance of operational rules and regulations, there will continue to be some impacts upon air and micro-climates.

1. Atmosphere

Strict enforcement of air quality standards cannot entirely eliminate atmospheric pollution by oil and gas operations. Air quality will inevitably be degraded, at least temporarily and locally, by engine emissions and dust arising from road and drilling site construction and from movement of surface vehicles. Well blowouts and accidental fires will occasionally add toxic vapors and particulates to the load of noxious materials already in the atmosphere. Despite the most advanced technology, refinery emissions will continue to cause some degradation of air quality.

The magnitude of such impacts may be significant only locally and temporarily; however, there may be some cumulative effects on the upper atmosphere (and hence on the earth's general climates) which are not yet fully understood (Maunder, 1969, pp. 21-29). Even short-term impacts on mammals could be significant if large amounts of pollutants are released in a stagnant air mass such as a temperature inversion or heavy fog (U.S.D.I., BLM, Preliminary Onshore Oil and Gas Environmental Statement, 1972).

2. Micro-Climates

The proposed actions cannot be implemented without some destruction of vegetation and related alteration of micro-climates (see Section VI -- F). Removal of vegetative cover for seismic lines, by construction of access roads and drilling sites, by well emissions, spills and accidental fires during the exploration, development and production phases will continue to some extent regardless of the mitigative measures applied. Even with careful rehabilitation during abandonment, some sites will continue to be barren and devoid of vegetation, perhaps for long periods (e.g., fragile ecosystems in the Cold Desert and Juniper sub-biomes). Micro-climates will be permanently modified in limited areas of continuing human habitation and on permanent road rights-of-way.

F. Vegetation

1. Terrestrial Vegetation

Mitigative measures can assist in minimizing the impact of most actions in the various phases of oil and gas operations. There is always the possibility, however, that accidental leaks, spills, or fires, etc., will cause adverse impacts that cannot be remedied. Similarly, there is always the possibility that planned rehabilitative measures, such as ripping of compacted soils, or revegetation of disturbed areas will be ineffective due to unforeseen circumstances. Particularly troublesome areas are most likely to be the Juniper sub-biome where knowledge is lacking regarding the vegetative measures necessary to restore many forms of native or introduced species, and the Coniferous Forest sub-biomes where development of a coniferous forest, similar to the one removed, is a long-term process; especially on unfavorable sites where many years are often required merely to establish tree seedlings.

2. Aquatic Vegetation

Some acquatic vegetation will be destroyed or buried by road or pipeline construction at streams, marsh or lake crossings. The loss in productivity would depend on the magnitude of destruction and would be long-term in nature, unless a similar amount of vegetation could be replaced elsewhere in the ecosystem.

The destruction of aquatic vegetation caused by a massive earth slide down a stream channel cannot be reasonably mitigated in most cases after the slide occurs. The impact would be severe and last many years.

Sedimentation of aquatic ecosystems will be increased above natural levels despite all mitigative efforts to prevent it. Unavoidable sediment deposits in streams and standing water habitats will result primarily from roads, trails and pipelines. Accidents during development and production will contribute additional sediment to streams and lakes. The long-term effects of excessive sedimentation are often more serious to aquatic plants in shallow-water habitats than short-term effects from a single pollution kill. Increased sediment shortens the natural life of ponds, marshes, lakes and estuaries by filling their basins, thus speeding up plant succession and eventual conversion to land. Aquatic vegetation is eventually replaced by terrestrial plants in this natural process. This conversion usually takes centuries to complete under normal conditions, but can occur in relatively few years if large increases in sedimentation occur.

Unmitigated loss of groundwater may occur in the Cold Desert because of limited supplies and slow recharge.

Many mitigative measures help minimize the impacts of most planned actions on aquatic vegetation. However, some severe short-term affects are unavoidable because of accidents, human error and mechanical failures. Leaks or spills from pipelines or storage facilities will occur periodically causing pollution of surface waters despite contingency plans and quick cleanups (U.S.D.I., BLM, Preliminary Onshore Oil and Gas Environmental Statement, 1972). As a result of these events, some aquatic vegetation will be killed by oil, saline water and toxic substances in drilling muds, fires and contaminated groundwater. Most of these impacts will be short term in nature, except in instances where large amounts of oil are spilled into streams or lakes, and prolonged pollution of aquatic habitats occur from sub-surface water supplies contaminated by oil, gas or briny water.

Operation of a terminal in one of Oregon's larger parts would result in some adverse effects on vegetation from oil spills that cannot be completely mitigated. Oil spills could originate from tanker accidents, cargo transfers at the terminal, transfers of ballast water at the terminal, and leaks in the transportation pipeline or storage facilities at the terminal despite all precautions.

Accidents at sea could result in oil spills and some short-term losses of marine plants. The magnitude of the losses of

phytoplankton and algae (including bull kelp) is not predictable due to the many variables relating to each spill. Since the majority of oil spills happen fairly close to shore, considerable amounts of oil would probably wash up on beaches. Effects in intertidal areas would tend to be short-term and not as serious as a large spill in an estuary.

Occasional oil pollution from small spills, leaks and effluents from terminals may happen. Where this occurs the effect on marine algae, phytoplankton and eel grass could be significant.

Technology has not developed methods to contain or recover oil effectively in the ocean. Tidal currents would spread oil rapidly in parts of an estuary. When such spills occur, impacts on marine vegetation will occur in intertidal zones of beaches and estuaries.

Several systems can be installed in an oil refinery to prevent losses of oil and toxic chemicals into receiving waters. However, based on past experience at refineries, some spills and leaks of oil and chemicals will occur due to human errors, mechanical failures, accidents, and deterioration of equipment and pipelines. The extent of damage to marine vegetation cannot be predicted. If chronic oil pollution occurs from small spills and refinery effluents, marine plants will suffer deleterious effects. The estuary will lose some of its basic productivity for an unknown period, and fisheries production will be reduced.

G. Animals

1. Terrestrial Wildlife

While most impacts on wildlife can be reduced through implementation of mitigating measures, some mortality or displacement of individuals is bound to happen. Exploration activities such as aerial reconnaissance, seismic testing, and wildcat drilling will affect wildlife to some degree.

Discovery and subsequent development of a producing oil and gas field will remove acres of land currently used by wildlife. Mitigation can avoid removal of critical habitat areas but removal of less important habitat will occur. Harassment caused by human activities in and around producing fields cannot be entirely mitigated. Larger species of wildlife, particularly predators, will be adversely affected (BLM, Preliminary Timber Environmental Statement, 1972).

Despite extreme caution in extracting, storing, transporting and processing oil, accidental oil spills may occur. Normally such spills can be mitigated through cleanup and restoration. Spills that occur on habitat essential to wildlife will have adverse impacts that cannot be mitigated for at least the time it takes to clean the site up, however. Lowering of water tables may occur if intensive development, such as refineries and company towns, take place in water short areas.

2. Aquatic Wildlife

Despite mitigative measures during exploration and development, increased soil erosion and sedimentation of surface waters will occur from roads, trails and pipelines. Some damage to aquatic resources will occur, the magnitude depending upon variables such as soil types, terrain, climatic conditions and degree of development.

The long-term ecological effects of excessive sedimentation of streams, ponds and lakes are often of greater consequence to aquatic species than are immediate, short-term effects of direct mortalities. For example, heavy sediment loads alter habitat conditions making surface waters shallower and warmer. This creates unfavorable habitat conditions for cold-water game species resulting in a predominance of undesirable non-game species or total elimination of cold-water fishes.

Even with good mitigative efforts, some short-term sedimentation can be expected below stream crossings, and from any approved gravel removal operations and channel changes (Impact Statement Proposed Trans-Alaska Pipeline, Vol. 4, pp. 526-527). This sedimentation would be short-term during construction. However, it could continue for several years during heavy surface runoff until disturbed areas are stabilized.

Landslides caused by road construction cannot be reasonably mitigated after they occur. They must be mitigated by thorough planning,

careful construction and proper maintenance, each of which can reduce their number and severity.

Culverts and channel changes could become barriers to the upstream migration of fish even though they were installed or constructed to meet fish passage criteria. Extreme floods or other unforeseen hydraulic problems could create temporary barriers to fish migration. Effects on fish would be short-term because these fish passage problems can usually be corrected in a timely manner.

The most important unavoidable impacts on water quality and aquatic life happen during exploration, development and production of an oil field. Accidental leaks, spills, explosions, fires and blowouts are bound to happen and they cause the greatest damage (BLM Preliminary Onshore Oil and Gas Environmental Statement, 1972). Well blowouts lasting days or weeks could occur despite all precautions. These would cause the greatest destruction of aquatic wildlife, especially if the oil flows directly into nearby standing or running-water habitats.

Pipeline leaks will occur and could cause considerable damage to freshwater fisheries. The magnitude and longevity of the impact would depend upon the volume of oil lost, water levels, sediment loads, location of the spill, and the season and temperature (Impact Statement Proposed Trans-Alaska Pipeline, Vol. 4, p. 528). Plankton, benthic organisms, insects, fish and spawning areas would likely suffer long-term effects from a large spill.

In spite of mitigative measures, some saline water is likely to enter streams and standing water habitats during handling

and disposal. Some short-term loss of aquatic life would occur. More serious losses of fish could occur during blowouts when large quantities of briny water (as well as oil and gas) flow directly into streams, natural ponds, marshes or lakes.

Contamination of surface waters by chemicals used in drilling mud can be prevented, except in the case of well blowouts during drilling. Harm to aquatic fauna from a blowout would depend on a number of variables, with impacts tending to be short-term in nature.

Unavoidable contamination of ground water can occur during a well blowout (oil, saline water and hydrogen sulfide gas), well drilling (toxic substances) and subsurface waste disposal during secondary recovery operations (U.S.D.I., BLM, Preliminary Onshore Oil and Gas Environmental Statement, 1972). Polluted aquifers may surface some distance from the source of contamination and enter surface waters, causing losses to aquatic species. Damage to aquatic ecosystems would progably not be great or lasting, unless an aquifer is badly polluted and discharges a relatively large flow into a small stream or pond.

Loss of ground water supplies which cannot be mitigated are causec by stratigraphic testing, well drilling, blowouts and secondary recovery operations (Ibid.). These actions could cause small springs, sloughs or ponds to dry up, resulting in the death of all aquatic species.

Unavoidable losses of water are most critical in the Cold Desert because of limited supplies and slow recharge of ground water.

Increased sedimentation and reduction of ground water supplies could result in complete loss of habitat for endangered desert fish species existing in isolated, small springs, ponds or streams. An untimely oil spill could also eliminate all species living in a restricted habitat. The effects of unmitigated losses of waters and sedimentation are nearly as harmful to fish populations in parts of the Palouse Prairie, Juniper, and Broad Sclerophyll sub-biomes as in the Cold Desert.

Construction of a marine terminal in one of Oregon's larger harbors would produce some unavoidable impacts on marine organisms. Human error during transfer operations, rupture by accidents and leakage due to corrosion and other deterioration of facilities annually contribute to significant oil pollution (National Petroleum Council, p. 71). Accidental spills of crude oil in the estuaries and the Pacific Ocean would result from breaks in the transportation pipeline and terminal storage facilities, cargo (crude oil) transfers at the terminal, transfers of ballast water from vessels to onshore separators, and spills from tankers.

Most oil spills could not be contained or recovered effectively in the ocean and parts of estuaries. Some of the worst impacts would therefore occur in the littoral and intertidal zones of beaches and estuaries.

Plankton are vulnerable to both acute and chronic (low-level) oil pollution. Acute pollution from infrequent large spills might do less permanent damage to plankton than chronic pollution

(Impact Statement Proposed Trans-Alaska Pipeline, Vol. 4, p. 543). Chronic oil pollution in one of Oregon's estuaries resulting from small spills and effluents from the terminal would have significant short and long-term effects on plankton populations. The loss in primary productivity would effect the food chain and thus the entire ecosystem of the estuary. In addition, both adult and juvenile shellfish, salmon, other food and game fish, and forage species such as herring would also be adversely effected. The extent of these impacts is unpredictable and would be dependent upon many variables, the most important being the volume of oil entering the estuary. Decreases in the yield of fish and shellfish to recreational and commercial fisheries would be expected from chronic oil pollution.

Accidents at sea can be expected to occur, causing some loss to marine species. Again, the magnitude of the loss of plankton and fishes cannot be predicted because of the variables associated with each individual spill. Over 80% of the past spills have occurred within 10 miles of shore. An accidental spill from a large tanker off Oregon's coast would undoubtedly result in substantial quantities of oil washing up on the shoreline. The resulting kill of intertidal animals would probably be short-term and not as serious as a large oil spill in an estuary where the oil would be concentrated in a relatively small area.

Location of an oil refinery in one of the larger coastal ports could be used to refine crude oil from an inland field as well

as oil received from tankers. The refinery would be an additional source of oil pollution. Mechanical failures, human errors and deterioration of equipment would result in more pollutants in the bay in spite of many systems designed to protect against loss of oil and toxic chemicals. Some large spills could be anticipated as well as an increase in the amount of chronic oil pollution. Water quality would be degraded further, and the magnitude of losses of aquatic organisms would be greater than without the refinery.

Construction of an oil refinery at an inland location would create a source of water pollution and probable loss of aquatic life. Oil and other toxic chemicals used in the refining process would occasionally contaminate surface waters because of the reasons listed in the preceding paragraph. The magnitude of the damage done to aquatic life would depend on many variables, but primarily the size and location of the refinery and receiving water of the effluent.

3. <u>Domestic Livestock</u>

Common to all sub-biomes is the short term impact on domestic livestock due to decreased vegetation resulting from oil and gas <u>exploration</u>, <u>development</u>, and <u>production</u>. Duration of impact is dependent on the length of time the area is actively used and the success in restoring vegetation following initiation of rehabilitation measures. The occurrence of accidental leaks, spills and fire can have a severe short term effect on livestock in all biomes due to the destruction of vegetation and contamination of water sources. The effects of accidental fires could have severe short term impacts if not quickly and properly controlled.

The following is a brief discussion of these biomes that deviate from general impacts that cannot be avoided.

a. <u>Palouse Prairie</u>

There is relatively minor value loss to domestic livestock in this sub-biome. With the exception of some roads and trails, vegetation can usually be quickly restored due to the generally favorable soil and climatic conditions.

b. <u>Cold Desert</u>

Effects of disturbances and accidental leaks, spills, etc., would be of no longer duration than in the <u>Palouse Prairie</u>. This is due to the generally lower productive capability of the land and limited knowledge of adequate mitigative methods necessary to restore

vegetation. This does not apply to the total area, however, as some sites can be rehabilitated rather easily. Sites that can be rehabilitated total about 20 percent of the land area.

c. Juniper

Most areas in the Juniper sub-biome are fragile in nature and difficult to revegetate. Some localized areas, however, are fairly productive and can be rehabilitated. In general, impacts on vegetation are difficult to mitigate and less likely to be successful than in the Palouse Prairie and more favorable Cold Desert sites. Some effects will be long term and unavoidable.

H. Micro and Macro Organisms

1. Soil Organisms

Some erosion will occur despite mitigation. Erosion reduces the volume of media for soil organisms. Therefore, less organisms will be sustained on site. The reader is referred to Section VI C (Soils) for parallel discussions. Factors which affect the soil also affect soil organisms.

2. Aquatic Organisms

Stream crossings or other activity which introduce suspended sediment into bodies of water which contain aquatic organisms is going to cause come damage to these populations. Leakage of brine or oil into these waters can occur through corrosion of pipelines of failure of containment structures. Damage to aquatic populations may occur through the discharge of hot water into a body of water even though the discharge may otherwise be of good chemical and physical quality. Failure of a well-designed sewage disposal system may allow effluent to reach streams, lakes, marshes, or estuaries.

I. Social, Economic and Land Use

1. Impacts Common to All Biomes

a. Health and Safety

Accidental deaths and injuries will take place despite safety measures. Where industry personnel are concerned, the magnitude of the problem from year to year is about directly proportional to the number of workers involved.

If proper precautions are taken (patrolling roads, signing, shutting down operations when climatic conditions warrant, etc.) to protect the health and safety of the general public, accidental deaths, injuries and health problems can be kept to a bare minimum. The hazards, however, cannot be completely mitigated.

b. Social, Economic, Cultural, Ethnic and Religious

The most obvious social impacts of oil and gas development will occur in areas inhabited by indigenous Americans, where cultural gaps are most apparent. Employment benefits are likely beneficial; associated cultural change has a more subtle effect (often negative, at least in the short-run), and can only be articulated by the native people themselves. Mitigation of such social impacts has, to date, been limited in effectiveness.

Social impacts are expected on comtemporary America when oil and gas development disrupts stable societies of rural areas. Ranching communities typical of the Cold Desert, for instance, represent such a life style.

Oil and gas production would have a significant beneficial effect on tax revenues of lightly populated areas which are not industrialized and lack tax sources. However, counteracting this effect are the aspects of development which would likely overtax public facilities and services and create inflated, unstable economies in the initial periods.

Depletion of reserves and economic recession must also be considered as a possibility which would reverse the beneficial long-term effects of tax revenues.

c. Land Uses

(1) Wilderness

Oil and gas development is basically non-compatible with wilderness land use by definition. Such development within areas of present wilderness quality would have a severe impact not capable of being mitigated, except over an extremely long period.

(2) Recreation

Roads and structures associated with oil and gas development change the character of the natural landscape. While increased accêss provides a beneficial impact to many recreational users (especially those using "off-road vehicles" for primary or secondary recreation purposes) the general impacts are adverse, at least until the abandonment stage. During development and operation, relatively small areas of several square miles are off-limits to recreationists. In terms of casual sight-seeing recreation, oil fields and facilities

are usually of interest to highway travelers; reactions may be favorable or critical of such operations.

(3) Mining

The unavoidable impacts on other mineral resources consist of the physical occupancy of potential mineral areas by oil and gas operations, the oil and/or gas production operational accidental explosions and fires in the area, and possible surface slumping.

The physical occupancy of the field, including areas for storage tank farms, collection and transmission lines and other operational improvements, will preclude the use of the site for other mineral development for the producing life of the field. The influence of this occupancy will extend for some distance in all directions from the center of the field or operation. Refinery operations could have an effect for an even longer period of time.

Fires resulting from accidental explosions and other causes are unpredictable and in some cases unavoidable. Unavoidable fires in timber can be completely crippling to other mineral operations. These fires could not only deplete the supply of timber for mine timbers, but could damage an entire mining operation to such an extent that it would be unfeasible or uneconomical to repair or continue in operation.

Surface slumping can happen after oil field abandonment despite precuationary mitigation measures. The resulting instability can make the area unsafe for the mining of other minerals.

(4) Forest Products

Residual negative impacts during the exploration phase on timber production are generally minor and limited primarily to

a temporary setback in timber production on relatively small areas. There is usually time to preharvest timber from oil field sites prior to development and to rehabilitate and reforest such areas after abandonment, except in cases of severe accidental oil spills, saline water contamination, soil compaction or loss of soil. Rehabilitative success, therefore, varies between forest types depending upon the actions applies, and it may not be possible to entirely restore some areas to their original productivity (See Section VI F 1)

(5) Agricultural

Disruption of grazing or intensive agricultural practices on a short-term basis can be expected on all sites on which such use is taking place (Also See Section VI G 3). Area taken out of production (roads, drill pads, ponds, etc.) may be significant when the land is of high productivity and oil and gas production extends over a period of years.

Except for uncertain large explosions, fires, spills of oil or other hazardous material, or severe compaction or loss of soil, the relative impact on a long-term basis is minimal.

(6) Urban Uses

Unless very rigidly regulated, oil and gas development would precipitate serious land use conflicts when occuring in residential, commercial, or industrial areas. Oil and gas operations would be entirely out of character with residential land use in particular. Unavoidable explosions, fires, or other accidetns could result in injury

or death to many people. Intensive urban uses occur in most sub-biomes and range from small settlements or villages to large metropolitan areas.

2. Significant Unavoidable Adverse Impacts by Individual Biomes

a. Palouse Prairie Grassland

The potential for unmitigated impacts is generally low in this biome. It would increase in proportion to the intensity of agricultural development of the area.

b. Cold Desert

This area contains a relatively great amount of unroaded areas, in a natural state to a great extent. Oil and gas operations could preclude subsequent wilderness or natural area use. Such values should be carefully weighed prior to undertaking activity.

c. Coniferous Forest

This biome has significant existing and potential wilderness values. Development is very likely to adversely effect these values. As in the Cold Desert, these values merit especially careful consideration before any development occurs.

J. Aesthetic and Human Interest Values

1. Aesthetics

There will be substantial unavoidable impacts on the visual environment during the operational periods of all phases of oil and gas production. Vegetation patterns are interrupted in all phases. Structures are placed on the landscape for varying time periods in the exploration, development and production phases. Some movement of soil will occur in all phases. Each of these actions interrupts the natural character of the landscape and none can be entirely mitigated.

After a field is abandoned, if the proper mitigating measures are taken, there should be very little adverse impact on the visual environment, with the exception of the Cold Desert due to its slow recovery rate. Other exceptions that would apply to all sub-biomes are roads or drill pads constructed on steep slopes. Complete reclamation and mitigation of these situations is not possible.

In most areas the aesthetic recovery rate may vary, but generally, over the long-term, recovery would be nearly complete. The grasslands will probably recover at a faster rate than other areas. The deserts will have the slowest recovery rate. The relatively high aesthetic values of the desert create the greatest potential for non-mitigated aesthetic damage.

2. Geological Values (Human Interest)

Where sites of geologic human interest are avoided, there will be no unavoidable impacts. Where activities occur on or near them, however, unavoidable impacts will occur despite mitigative measures.

3. <u>Archeological Values</u>

With careful planning and care, there should be few impacts that are unavoidable except for the uncovering of archeological sites which are hidden beneath the surface. Here adverse impacts of partial destruction are bound to occur unless the sites were located and marked in advance. Some damage by vandals is likely to occur where access roads and development bring people into or near archeological sites.

4. <u>Historical Values</u>

With careful planning and on-the-ground resourcefulness there should be no impact to known and recognized historical sites. Some sites could, however, be damaged or destroyed due to unavoidable accidents or vandalism.

5. <u>Cultural, Ethnic and Religious Values</u>

Because of the nature of our society and its emphasis on free choice of the individual, there will be certain impacts that are unavoidable. When two cultures meet, there will be change - and both groups will be changed to some extent. Depending on various points of view, some of it will be detrimental and some will not. To assess how negative or positive such impacts are would constitute a value judgment.

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VII. Short-Term Use Versus Long-Term Productivity

Oil and gas leasing may or may not represent a short-term use. Simple surface exploration, if carried no further, would constitute a short-term use. Discovery and development of a producing oil or gas field would, on the other hand, constitute a long-term use, perhaps for several decades. We are not concerned in this section, however, with a definition of short-term use, but with long-term productivity. More precisely, how will long-term productivity of the area be affected after oil and gas activities have ceased and reclamation, insofar as possible, has been completed.

A. Ecological Interrelationships

The balance of nature is a complex thing. Man must learn to understand the basic principles and laws governing the entire living community if he is to be successful in maintaining the productivity of the earth (Storer, 1953, Introduction - p. VI).

Productivity is usually indicative of an ecosystem's stability. Highly productive ecosystems are generally in good equilibrium, while the natural balance is fragile in communities of low productivity (Darling and Milton, 1966, p. 53; Kormondy, 1969, p. 153). Short-term actions (e.g., oil and gas operations) pose their greatest threat to the continuing productivity of ecosystems containing species of plants with low growth rates and animals with low reproduction rates. Such ecosystems recover slowly from abuse (Darling and Milton, 1969, p. 53).

These conditions are characteristic of the Cold Desert and Juniper Woodland sub-biomes. To a lesser extent, they also exist in portions of the Montane Coniferous Forest. Where fragile communities have already been damaged or modified by previous activities, long-term productivity may be significantly reduced by the introduction of a new short-term use, such as exploration for oil and gas, or longer use such as development and production. In any sub-biome, the natural balance will be altered and long-term productivity reduced where permanent roads and structures are installed and where mass soil movement exposes bedrock.

The productivity and ecological equilibrium of aquatic habitats (streams, lakes and coastal estuaries) can also be permanently affected by actions associated with oil and gas operations.

B. Physiography, Geology and Minerals

Short-term use in a geologic sense is that time during which the oil or gas field has gone through the four phases of operation including exploration, development, production and abandonment. This time frame may vary from 20-40 or more years, depending on the size of the producing area.

If oil and gas were discovered in Oregon these resources would be produced, transported to market, and consumed mainly in the production of energy. Thus, the short-term consumption of this part of man's environment would preclude any long-term productive use of those hydrocarbon reserves for energy or non-energy purposes, including use as raw materials (Final Environmental Impact Statement, Proposed Trans-Alaska Pipeline, Vol. 4, p. 586).

If geologic subsidence or seismic activity occured as a result of oil and gas activities, impacts caused by such subsidence and seismic activity would be of extremely long-term.

C. Soils

Long term productivity is lost or reduced in all sub-biomes when the soil is disturbed, eroded or compacted. Productivity loss due to erosion has the greatest longivity, soil disturbance the shortest, and compaction is intermediate. Areas with very severe treatments, such as those covered with mud pits, structures, roads, and toxic waste disposal sites will have a very long term loss in productivity.

Ability of the soils to rehabilitate themselves is slower in the Cold Desert and Juniper sub-biomes than it is in the other sub-biomes. However, loss due to mass wasting is greater in the Coniferous Forest.

D. Water

Many of the adverse impacts of oil and gas on surface waters will be temporary provided that effective mitigating measures are utilized. An example is the increase in suspended sediment concentration during the construction of permanent stream crossing structures. However, careless stream crossings of failures of well-designed crossing structures can result in the deposition of tremendous quantities of debris and sediment in stream channels. In the Coniferous Forest area many of these streams drain into estuaries, in the Cold Desert and central Montane streams drain into the Columbia River. Debris-choked streams may take decades to regain equilibrium between the amount of sediment discharged and the amount received. Reservoirs may have valuable storage capacity permanently reduced by this volume of sediment -- this is especially critical east of the Cascades.

Contamination of ground water aquifers can be a permanent effect although it may take many years for the effects to be noted in a water supply if it is a long distance away. Many ground water aquifers are not considered to be usable water supplies, either because of their great depth or economic factors. However, technological advances and/or changes in the economic picture may make these aquifers usable, but prior contamination could preclude their use.

E. Climate and Air

1. Atmosphere

Potential long-term impacts of man-caused air pollution are unpredictable because basic research is not far enough advanced for good evaluation. However, it has become apparent that man's modifications of the earth's surface, and other human actions, do change the atmospheric environment, particularly the temperature and moisture balance (Maunder, 1969, pp. 21-29). Although evidence is not yet sufficient to prove the theory, there is a possibility that man's influence on the atmosphere can cause climatic changes of continental scale. This possibility cannot be ignored (Ibid.). Such changes of general climates would very likely alter the capability of various ecosystems for producing vegetation useful to man.

The oil and gas industry is only one of many contributors to the load of noxious matter in the earth's atmosphere. Still, the cumulative effect of gases, vapors and solid particulates arising from man's activities is not yet fully understood. Even with air quality standards and controls, the sum total of permitted emissions of air pollutants may, with accelerated human activity, exceed the recuperative power of the atmosphere over vast areas of the earth (Rossano, 1969, pp. 11-20). It is within this context that oil and gas operations must be considered. Therefore, we cannot safely assume that there is no significant potential for long-term degradation of air quality. We do not really know.

2. Micro-climates

The long-term micro-climatic impacts of practices which destroy vegetation will vary from sub-biome to sub-biome. In all sub-biomes, micro-climates will be permanently modified in limited areas; e.g., where roads continue to be maintained and used, and where there is continuing occupation of communities established to support oil and gas operations.

After abandonment, restoration of vegetation and corollary recovery of micro-climates will occur most rapidly on moist sites in the Coniferous Forest, particularly in the mild general climate of the Northwest Coastal Coniferous Forest. Slow recovery can be expected on sites exposed to the severe general climate of the Cold Desert and Juniper sub-biomes. Under the xeric conditions and short growing seasons characteristic of these sub-biomes, restoration of original micro-climates could require many decades. Meanwhile, productive capacity (in terms of forage for wildlife and livestock) would be significantly reduced.

Without adequate scarification, the residual effects of soil compaction can inhibit the natural restoration of vegetation (and micro-climates) for decades on and near abandoned drill pads, roads, airstrips and campsites. Soil contamination by waste brine can also have long residual inhibiting effects on plant growth, particularly in areas of low annual precipitation, where leaching proceeds slowly.

F. Vegetation

1. Terrestrial Vegetation

Generally speaking, man's short term use of the land for oil and gas operations will generally have a minimal impact on long-term productivity of terrestrial vegetation provided the necessary mitigative measures are carried out. Vegetation is a renewable resource that can be re-established where adequate consideration is given to preserving the necessary environmental conditions. Where such consideration is not adequate, however, and actions occur that damage, or destroy soil or water to the extent that technological or economic limitations preclude rehabilitation, the consequence can be the absence or reduced growth of appropriate terrestrial vegetation for extended periods of time, i.e., reduced long-term productivity. It is possible that actions in any sub-biome will, for example, cause damage to soil or water that results in absence of any form of higher vegetation such as grass, brush or trees for several decades. A more likely possibility, however, is that a particular action may reduce site productivity only to the extent that production of the specific type of vegetation removed is seriously impared, e.g., following oil and gas operations it may be possible to produce only forbs or brush on a site formerly occupied by coniferous forest, or sagebrush where grass was dominant. Impairment of the ability of the site to continue production of earlier vegetation, therefore, constitutes a reduction in long-term site productivity.

2. Aquatic Vegetation

The long-term productivity of aquatic plants can be reduced by oil and gas operations. Accidents, human errors, and mechanical failures can happen despite efforts to mitigate them. Other losses of vegetation are unavoidable. For example, vegetation destroyed or buried at water crossings of roads and pipelines will result in reduced long-term productivity.

Large oil spills reaching surface waters can have a detrimental long-term impact on vegetation in a localized area if the oil cannot be removed soon. Prolonged pollution by oil, gas or briny water from a contaminated surface water supply after abandonment could also reduce long-term productivity.

Massive earth slides in stream channels cause moderate to severe long-term losses in productivity of riparian vegetation in the impact area of the slides. The long-term effect of increased sedimentation from other actions is to shorten the life span of some aquatic ecosystems, thus eliminating aquatic plants from the environment sooner than under natural conditions. Aquatic vegetation in small springs or lakes could also be lost if shallow-water aquifers are drained during well drilling. Loss of ground water supplies would have its greatest long-term impact on aquatic vegetation in the Cold Desert and part of the Palouse Prairie and Juniper sub-biomes.

Accidents, mechanical failures and deterioration of pipelines and equipment at marine terminals and refineries could result in

significant oil pollution of estuaries. Chronic pollution will cause long-term loss of aquatic vegetation during and after operations at the facilities have stopped. Production of algae, phytoplankton, and eel grass would all be adversely affected causing reduced production of all organisms throughout the food chain.

G. Animals

1. Terrestrial Wildlife

Short term use of the lands for general exploration activities will not, as a rule, impair long term productivity for wildlife, with the exception of some endangered species. If oil is found, however, subsequent development and production can have a long term effect on wildlife through loss of crucial wintering, breeding, production and migration areas. In these cases both the habitat and wildlife can be lost. After production and site abandonment, the ecosystem may never be entirely rehabilitated. Human settlement that takes place during development and production may persist after petroleum production has been exhausted. Thus, wildlife formerly found in the area may never again use it due to changes in land patterns and use.

Smaller, more adaptive wildlife species such as ground squirrels, rabbits and other mammals, birds, and insects, and the small predators that depend on them, may reinhabit the peripheral zones of their former habitat. Exotics such as pheasants and chukar, and Hungarian partridges may find the change in land patterns to their liking, especially if agricultural development has occured.

Impacts on wildlife habitat and food supplies that might be short term and reasonably susceptible to rehabilitation in other sub-biomes could very easily be long-term on the desert (U.S.D.I., Preliminary Onshore Oil and Gas Environmental Statement, 1972).

2. Aquatic Wildlife

Oil and gas operations have some impacts on the long-term productivity of aquatic wildlife. Natural sedimentation is accelerated by all phases of oil and gas operations. The long-term ecological impact on streams and lakes is one of reduced production of indigenous cold-water fishes. Habitat conditions become favorable for non-game species that thrive in warm waters, while preferred cold-water species are either reduced in numbers or eliminated from the area. Some aquatic insects and benthic organisms are affected in a similar manner by drastic changes in habitat conditions caused by sedimentation. Massive earth slides triggered by road construction can continue to occur after an oil field is abandoned creating further adverse long-term impact on streams.

Substantial oil pollution of aquatic ecosystems from blow-outs, leaks and spills throughout the life of the field would reduce the long-term biological productivity of nearby streams and lakes. Unmitigated sources of oil pollution, especially if draining into surface waters, could reduce production of aquatic life over the long-term.

Ground water polluted by oil, saline water, and hydrogen sulfide could continue to surface in an aquifer and contaminate surface waters after an oil field is abandoned. The impact may not be serious unless the aquifer is heavily polluted and discharges a relatively large flow directly into a stream. In this case, the long-term impact would be reduced production of aquatic life rather than total loss.

Accidents, human error and deterioration of equipment during operations of marine terminal sand refineries could result in significant

oil pollution of estuaries. Significant loss of marine life, especially in estuaries could be expected during use of the facilities, and possibly for a number of years after termination of operations. Plankton would suffer long-term adverse effects from oil pollution, as would populations of larger species heavily utilized by man -- shellfish, salmon, crabs, bay fishes, etc. Production of these species in recreational and commercial fisheries would therefore be diminished. Refinery operations could cause long-term reductions in fresh water species if the effluent was discharged directly into rivers or lakes.

Consumption of surface and ground water during exploration, development and production phases of oil and gas operations is a short-term depletion of water supplies that could have long-term effects on some aquatic habitats and fish populations. Ground water levels and aquifer pressures may be lowered, thus decreasing the flow of springs. During some years this could eliminate small springs, marshes or ponds that are habitat for some species of fish.

Any of the four previously discussed impacts (sedimentation, contamination of ground water, oil pollution and loss of ground water) could result in long-term deterioration or destruction of the only remaining habitat of an endangered aquatic species.

The Cold Desert and parts of the Grassland, Juniper and Palouse Prairie are water deficient areas where the long-term impact of reducing available water supplies can be detrimental to aquatic ecosystems and fish life. The short-term use of water in large quantities during well drilling would have the most detrimental impacts on aquatic habitat in the Cold Desert where most endangered species of fish exist.

3. Domestic Livestock

Generally short-term use of the land by oil and gas operations will have minimal long-term effect on domestic livestock providing necessary mitigative measures are carried out. Most long term effects to livestock will occur indirectly through changes in vegetation. Vegetation is a renewable resource capable of re-establishment on most areas that are denuded during normal activities.

Through revegetation and protection, the productivity of denuded areas can generally be restored. There may be a serious impact on the long term productivity of localized areas due to accidental leaks, spills, and other unplanned actions.

Each sub-biome has certain characteristics that influence its potential for full productive recovery.

a. Palouse Prairie

Long term productivity losses and their effect on domestic livestock will usually be minor in this sub-biome. Revegetation of disturbed areas occurs rapidly due to favorable soil and climatic conditions.

b. Cold Desert

The generally lower productive capability of the basic resources in this sub-biome increases the risk of long term impacts on vegetation and domestic livestock.

When disturbed, existing fragile ecosystems are subjected to longer periods of wind and water erosion and top soil

loss. This increases the probability that long-term impacts will occur.

c. Juniper

Long-term productivity lost due to short-term use will be similar to that described in the Cold Desert sub-biome.

d. Northwest Coastal and Montane Forests

The removal or destruction of vegetation from thin soil mantles in steep terrain can lead to massive land slides. The resulting exposed rock surface eliminates the possibility for re-establishing vegetation and long-term productivity is reduced. Affects to domestic livestock are minimal due to the type and amount of grazing use made. Areas used by livestock are limited to the more sparsely timbered open grassland and meadow types.

e. Broad Sclerophyll

Long term effects to domestic livestock in the steeper areas will be similar to those in the montane and northwest coastal sub-biome. Long term effects on remaining areas will be moderate due to the favorable soil and climatic conditions.

H. Micro and Macro Organisms

1. Soil Organisms

Soil organisms probably respond faster to changes than any other portion of the soil. Populations will recover if there is an energy source and the soil is inoculated. Vertebrates will reinhabit areas if conditions are favorable. The reader is referred to Section VII C (Soils) for additional details as actions affecting soils have similar effects on soil organisms.

2. Aquatic Organisms

Damage to the productivity of the aquatic environment through short-term pollution by organic wastes (sewage effluent, for example), is likely to be temporary. Sensitive organisms will die or leave the area, tolerant species will flourish, and upon cessation of pollution, the aquatic community will regain its former composition.

Leakage or dumping of brine, oil, or chemicals into bodies of water may cause long-lasting reduction of productivity. These effects will be longer in marshes and lakes in arid or semi-arid areas where inflow of water may be limited. Some of these pollutants may be so toxic that certain species may be completely eliminated. Thus, loss of productivity may be reduced for decades, or even permanently, if the eliminated species has a commercial value, or if it forms a vital link in the food chain.

It is worth noting that marshes and estuaries are the two ecosystems which are most susceptible to long-term reduction in productivity. This is becuase their inherent productivity is high and these areas often provide indirect benefits to other organisms which may spend

only a short time in the marsh or estuary. For example, waterfowl which rest in these areas during their seasonal migrations would be subject to injury or death as a result of an oil spill. Thus, the reduction of these indirect additions to total productivity should be considered.

I. Social, Economic and Land Use

1. Social and Economic

Social and economic decisions have a natural tendency to place greater emphasis on short term objectives. Local benefits - primarily economic - are more easily identified than social or long range economic impacts which are also associated with oil and gas activity. It is difficult to maintain a time frame reference which concerns itself with future generations. Immediate economic return must be balanced with consideration of less tangible social factors and the possible long term adverse effects.

Unique social or cultural values are tangible in that they can be described - although not usually in economic terms. Loss of unique cultures or life styles would result in a decrease in long-term productivity, in that there would be reduced social diversity.

Significant impacts on long term productivity may be incurred if there is insufficient knowledge on which to base planning decisions, or if available resource information is inadequately considered. Improper decisions could result in impairment of long term social and economic resources which are unique and important to future development of the locality.

As noted earlier, the bulk of oil and gas production is likely to occur in lightly populated rural areas presently lacking large industry. Thus, short-term use can have a long term impact as this resource is depleted.

2. Land Use

Land use patterns resulting from intensive development establish trends which are difficult to change, and impact long-term use and productivity. Oil and gas activities, inappropriately located, can result in land use conflicts which may continue into the future, reducing the productivity of other uses. Development of oil and gas production facilities, if not closely coordinated with other mineral development, could impose constraints making utilization of other mineral deposits uneconomical, reducing future productivity. Impairment or destruction of unique recreational resources would adversely affect the future development and productivity of these resources. This is particularly true in the Coniferous Forest. Here, climatic conditions, topography, etc., are conducive to year round utilization by recreationists - including winter sports. Tourism - recreation economies are significant, based on inherent recreation values. Any impairment of these values would adversely affect long-term use for recreation - tourism. The same is true for some portions of the Cold Desert, Juniper, and Broad Scherophyll areas. In desert areas where scars on the landscape tend to be long lasting, degradation of the landscape could render it unsuitable for recreation homesite use.

J. Aesthetic and Human Interest Values

1. Aesthetic Values

There are very definite effects on aesthetic values during short-term use. However, if proper mitigation and rehabilitation measures are taken, there should be relatively little impact on the long-term aesthetic values.

The short-term use, however, can be a relatively long period of time. Since so many scenic values are present in Oregon, very careful measures should be taken to protect and preserve areas of scenic significance during the short-term use.

Particular care must be taken in desert areas. Many scenic values are "fragile" and scars on the landscape associated with vegetative and soil changes are very slow to heal. Permanent damage can occur very easily if proper mitigating measures are not taken.

2. Geological Values of Human Interest

The chance of damage to geological structures is slight if precautionary measures are taken during operations. Any damage that does occur, however, would become a long-term impact.

Definite impairment of values occurs during short-term use to the interest value of unique or aesthetic geological formation where facilities are placed too close. However, there should be no lasting long-term loss to the human interest values if proper abandonment procedures are followed.

3. Archeological Values

Short-term use of oil and gas sites with archeological resources can sometimes be beneficial, particularly in areas where little

knowledge has been previously available. This can serve as the basis for long-term planning for the total archeological resource. On the other hand, short-term use may represent the least efficient use of the archeological resource because of the state of the art at time of discovery and the "hurry-up" protection and salvage methods dictated.

Short-term uses that alter or destroy archeological sites will, of course, have long-term impacts on the productive value of those sites.

4. Historical Values

Danger of short-term or long-term impacts to historical values can be minimized if proper care is exercised. The greatest danger is complete loss of an historical value by obliteration due to lack of knowledge of its existence.

5. Cultural, Ethnic, and Religious Values

These values undergo natural long-term evolutionary changes. It is difficult to separate these changes from long-term effects of particular impacts. Also whether some long-term changes are "damaging to productivity" is a value judgment in many cases - influenced by the cultural, ethnic and religious background of those who sit in judgment.

Thus, while short-term impacts can be fairly readily identified - whether judged good or bad; the long-term "productivity" effects on values such as these becomes impossible to resolve. There will certainly be long-term changes due to the impacts of oil and gas development, particularly in the culture and life styles of affected areas.

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VIII. Irreversible and Irretrievable Commitments of Resources

This section discusses impacts associated with oil and gas leasing activities that result in irrevocable uses of resources. Extraction and eventual consumption of oil and gas is perhaps the foremost example. However, massive errosion, destruction of human interest values, elimination of endangered species, and irrevocable changes in land use would also fall within this section.

A. <u>Ecological Interrelationships</u>

Occasional situations occur in which the natural balance has obviously been damaged beyond repair. One example is the exposure of bedrock by mass soil movement, where restoration of a life-sustaining abiotic environment can be accomplished only by natural processes operating over a period of geologic time.

Irreversible and irretrievable commitments of resources for each component of the environment are discussed in the following parts. Where such commitments occur, they will affect other resources to some degree, whether or not the other resources were themselves initially affected by oil and gas activities. For example, loss of the soil mantle in the situation above would alter the vegetation, which could affect wildlife using it for habitat; it could alter the micro-climate for that site, etc.

B. Physiography, Geo. and Minerals

The major irreversible impact on the geologic resources would be the consumption of natural construction materials such as sand and gravel for the development of the oil field. The terrain from which these materials would come would be modified by the development of gravel borrow pits and rock quarry sites. The consumption of the oil and gas resource itself would be irreversible and irretrievable.

C. Soils

In all sub-biomes, actions which destroy topsoil or cause erosion can have a permanent impact upon the soil. The magnitude of the impact can be reduced by the mitigating actions. Total commitment of the soil resource was estimated to be 1/6 to 1/4 of the oil field surface (U.S. Dept. of Interior, 1972). This commitment is mostly due to production facilities and the transportation system. During the period of field and related operation, loss of soil covered by structures, roads, and facilities would be irreversible. Some areas heavily oil soaked or eroded away would represent irreversible losses.

D. Water

If there were no accidents or failures in any phase of oil and gas activity then there would be no irreversible and irretrievable commitments of the water resource. However, accidents and failures are bound to happen in spite of precautions. In these cases, surface reservoirs can suffer permanent loss of storage capacity because of increased sedimentation. Ground water aquifers can suffer permanent loss of water quality because of contamination with pollutants.

If subsidence occurs in formations containing underground water aquifers during the life of the field, the aquifer would be irretrievably lost. Subsidence cannot be reversed, nor can aquifers where subsidence occurs be recharged.

E. Climate and Air

1. Atmosphere

Theoretically, properly conducted oil and gas operations should have no irreversible or irretrievable impacts upon the atmospheric resource. Mitigating measures should reduce adverse effects to a level within the natural capacity of the atmosphere to purify itself. However, the impact of air pollution attributable to oil and gas operations cannot be evaluated alone. It must be considered as an integral part of the total load of noxious airborne material created by all of man's activities; e.g., industrialization, urbanization, and a rising standard of living which consumes energy and creates air pollution at an accelerating rate (Rossano, 1969, pp.11-20).

Air quality degradation has become a severe local problem in many urban areas during recent years. It has also become a continental problem, even a world problem, at lesser (but increasing) levels of intensity (Ibid). The trend could be reversed by concerted national and international action. However, against the historical background of industrial growth in Europe and America (which continues) and with the deisre of the developing nations to achieve the same goals of economic expansion, the present outlook is not hopeful.

2. Micro-climates

Given enough time, vegetation destroyed by oil and gas operations can be restored and original micro-climates recovered. Natural restoration may take a long time, particularly in sub-biomes where the

general climate is severe; e.g., the <u>Cold Desert</u> and <u>Juniper</u>. However, there is no irretrievable commitment to any fixed micro-climate, unless massive loss of soil occurs, exposing sterile bedrock (See Section VIII F 1). Local climates are regulated by vegetation, and vegetation is renewable.

F. Vegetation

1. Terrestrial Vegetation

Irreversible or irretrievable impacts on terrestrial vegetation could occur if oil and gas operations cause total, or near total loss of soil. Loss of an entire plant species such as Port-Orford cedar, currently threatened by a killing disease, would also be an irreversible or irretrievable impact.

It is very unlikely that oil and gas operations will impact the land to the extent that much soil would be destroyed if sincere efforts are made to observe mitigative measures recommended for protection of soil, water, aquatic wildlife and aquatic vegetation as well as terrestrial vegetation.

It is quite possible, however, that oil and gas operations inside the natural range of Port-Orford cedar could contribute significantly toward demise of the species prior to development of techniques for protecting the remaining cedar population.

2. Aquatic Vegetation

Loss of ground water aquifers could permanently dry up aquatic habitat resulting in an irretrievable loss of aquatic vegetation in small springs or lakes, especially in the Cold Desert and parts of the Juniper and Palouse Prairie sub-biomes.

The natural process of the conversion of standing water habitats to land masses is accelerated by various actions of oil and gas operations that contribute to sedimentation. Massive earth slides are the most drastic events in localized areas, but the cumulative effect of increased sediment from other actions can cause the greatest offsite effects on aquatic plants.

Aquatic vegetation destroyed by road and pipeline construction at water crossings would generally constitute a minor irretrievable loss of vegetation if plants could not be reestablished.

G. Animals

1. Terrestrial Wildlife

The loss of any endangered species constitutes an irreversible and irretrievable commitment. Small, non-mobile species dependent on a microsite, or other limited habitat with only local distribution, such as the Siskiyou Mountain salamander, are especially vulnerable. Other more mobile species, such as the northern spotted owl and Columbian white-tailed deer, could be eliminated from an area for a long period of time. Whether this would be irreversible is not known.

Discovery and development of an oil field may result in permanent urban development. The loss of habitat and attendant human activity could result in the loss of displacement of major game species and the larger predatory birds and animals (BLM Timber Preliminary Environmental Statement, 1972).

Heavy industrial and domestic use of water may lower water tables, draining marshes and other wetlands. Waterfowl, other birds, amphibians, and small mammals formerly inhabiting these wetlands may be displaced to other areas or permanently lost.

Vegetation removal and soil disturbance associated with oil and gas operations can cause siltation of bays and estuaries, permanently damaging the habitat for birds, marine animals, and invertebrates.

2. Aquatic Wildlife

Excessive sedimentation can cause irretrievable changes in aquatic habitat when stream channels, lakes, marshes or reservoirs become filled with sediment. These habitats are no longer capable of producing the quantities of fish they once did unless the sediment is physically removed, which is generally considered impractical.

While other activities in the watersheds contribute to increased sedimentation, oil and gas operations would accelerate sedimentation of surface waters during exploration, development and production. Massive earth slides caused by activities in steep terrain are the best illustration of the adverse effects of heavy sedimentation in a localized area. Aquatic habitat lost to sedimentation is seldom restored by natural processes. Loss of productive area in estuaries due to accelerated sedimentation is another example of an irreversible commitment of aquatic resources.

Extermination of an endangered species or subspecies of fish is an irretrievable or irreversible action. Most endangered fish species in Oregon are found living in sometimes harsh, isolated, small habitats of the Cold Desert sub-biome. These endangered species could be made extinct through direct eradication by an oil spill, loss of water supply or ground water contamination. In these cases the habitat could recover in time, but the species would be lost. Endangered fish could also be lost by habitat changes that the species could not adapt to e.g., extensive sedimentation of a small spring or pond.

3. Domestic Livestock

There are no known irreversible or irretrievable impacts of oil and gas activities on domestic livestock. Some damage, including death, might occur to individual animals through direct contact with contaminated water, volatile gases or the indirect destruction of vegetation. Vegetation is a renewable resource and only in the case of the extinction of endangered plants valuable to livestock would damage be irreparable. Severely impacted areas may remain bare of vegetation for a considerable period, to the extent that they are incapable of supporting beneficial forage plants in the long-term future, this would be an irretrievable impact. Under most circumstances, however, such areas will be minimal if proper mitigative measures are followed.

H. Micro and Macro Organisms

1. Soil Organisms

Soil organisms will recover to the degree that the soil in which they live is rehabilitated or conserved. Erosion reduces the habitat for organisms. In such cases, habitat loss is irreversible (See Section VIII C, Soils for additional details).

2. Aquatic Organisms

Estuaries and marshes can lose so much of their volume through sedimentation so as to render them permanently damaged. Oil and/or toxic materials may eliminate entire species or groups of species and this may so reduce productivity that it becomes a permanent loss. The only way that productivity might be restored would be to allow time to dilute or dissipate the toxic material to tolerable levels and then re-introduce the missing species.

I. Social, Economic and Land Use

1. Social and Economic

Community life and social patterns which are altered by the population increase and economic growth caused by oil and gas operations could be a one-way affect of development. Although prior economic environments might return after operations ceased, and no new economic activity developed during oil and gas activities , it is doubtful that social aspects would ever revert back.

2. Land Use

Oil and gas operations have their greatest impacts in areas which are presently in a natural or near natural condition. Natural ecosystems can be altered in the immediate area to the extent that restoration is either completely impossible, or unfeasible for all practical purposes. In any case restoration to precisely the original situation would be impossible. The significance of the loss depends on the uniqueness of the area or resource impacted. The effect would be irreversible in wilderness or rare natural areas. Recreational activities that depend on the uniqueness of a site or area would be impacted to the extent of being irretrievable.

Urban land uses resulting from oil and gas development will establish patterns and trends which would be extremely difficult to alter. This aspect could be considered an irreversible commitment.

J. Aesthetics and Human Interest Values

1. Aesthetics

If properly planned and carried out, careful mitigation and rehabilitation measures should be able to nearly restore aesthetic values in many areas. The length of time necessary for restoration would vary greatly. Certain areas of the desert might require relatively long periods to recover - to the point where aesthetic value losses could be considered irretrievable for all practical purposes. Other areas, such as steep slopes or mountains where earth slides occured during operations, may never be retrieved.

2. Geological Values (Human Interest)

Development of oil and gas is not likely to represent an irreversible or irretrievable commitment of geological values of human interest, even when located in an area containing such values. The reason is simply that most geological features are too large and sturdy to destroy by such activities and, usually, upon abandonment the districting scar soon heals. The exception would be small, fragile geologic features (e.g., a small volcanic cinder cone). Here, the quantity and quality of similar features nearby would be a pertinent consideration in deciding whether destruction is tolerable. However, such reasoning could allow a site-by-site cumulative destruction to progress, which would end up in an irretrievable commitment of resources.

3. Archeological Values

Archeological excavation represents, in a way, use that alters the resource as it is salvaged and excavated. By forcing the

archeologist to salvage some sites from an unknown quantity of resource, he is forced to use up that resource now with today's techniques without regard to research problems, or anything but a dim view of the future.

To keep ahead of oil and gas operations in a developing field, the archeologist may be forced to remove the entire archeological resource of certain historic and prehistoric cultures without saving any for the future (this has happened in some of the salvage operations in the Missouir River Basin program).

4. <u>Historical Values</u>

Historical structures and sites are each unique and irreplaceable. Once destroyed or impaired, such structures and sites are never really the same and the more they are impaired the less reality they protect for the visitor. Impairment can be a cumulative thing so that after a long period of time nothing really original or authentic exists. Much of the understanding of what happened in the past is related to the present similarity of the site to its appearance at the moment of historical importance. Restoration and reconstruction are effective "cosmetic" measures, but it must be recognized that cosmetic approaches are not completely real or honest.

5. <u>Cultural, Ethnic, and Religious Values</u>

Any change is, in a sense, irretrievable and irreversible. The best that can be hoped for is that the cultural stock will not disappear or be completely absorbed so that these values will be saved in some form so that all may benefit from the culture's experience. Generally, most cultural, ethnic and religious values are rather endurable features that transcend most such localized impacts as oil and gas development.

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IX. Alternatives to Oil and Gas Leasing

This section presents 16 alternatives to oil and gas leasing. All were originally formulated for the national programmatic statement for oil and gas leasing, and are felt to be applicalbe to oil and gas leasing in Oregon, since adoption of any or a part of them on a national scale would effect Oregon.

Alternatives 14, 15, and 16 are considered the most viable for Oregon, since Oregon has no known geologic structures for oil and gas.

so where does 500MBD + 2.5 billion cfd come from?

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1. <u>Increased Imports</u>

Prior to the final preparation of this section, the working group of the Oil Policy Committee was consulted and suggestions were made on how to improve the analysis. This section has been revised as a result of these comments.

a. <u>Description of the Alternatives</u>

Based upon the Department of the Interior's Economic and Security Aspects of the Trans-Alaska Pipeline Analysis, estimated 1980 oil demand will most likely be 22 million barrels per day. Projected domestic production deficits relative to that projected demand under the various assumptions considered, range from 8 million barrels per day (41% of demand) to as high as 16.2 million barrels per day (65% of demand). Such deficits must be provided for either by (1) reduction in demand as discussed later in this statement, (2) increased oil imports, or (3) development of additional sources of domestic supply, or a combination of 1, 2, and 3. To the extent that the acreage from the proposal were not leased, an alternative would be to increase oil imports above already expanded levels by an amount equivalent to the expected production. Assuming the continued availability of foreign oil supplies at competitive prices, two Federal actions could open the way for increased oil imports. First, oil import quotas can be increased in almost any quantity and manner within the context of the existing Mandatory Oil Import Program including removal of controls. Second, all oil import quotas could be replaced by a tariff system designed to limit oil imports. The extent of oil imports under restrictive tariffs

would be primarily a function of rates imposed, the relationship between foreign and domestic oil prices and transportation costs. A major issue is the extent to which oil import controls are needed to maintain domestic production capabilities required to meet national security needs.

Assuming that there would be no substantive change in U.S. energy policy, analysis indicates that oil imports will need to increase rapidly in the eastern and Gulf regions. First indications of this increase are already apparent in 1972. The analysis in this section relates primarily to incremental imports equivalent to the amount of oil and gas expected to be produced from the proposal.

(1) Mandatory Oil Import Program

Imports of crude oil, unfinished oil, and oil products are controlled under the Mandatory Oil Import Program established in 1959 by Presidential Proclamation 3279 (17). The statutory foundation for Presidential action started with Section 2 of the Trade Agreements Extension Act of 1954 which prohibited any decrease in duty on any article if such reduction would threaten domestic production needed for national defense. Section 7 of the Trade Agreements Extension Act of 1955 added a sub-section (b) which authorized the President to restrict imports found to be threatening to impair the national security. It established a two-step procedure: an opinion by the Director of the Office of Defense Mobilization (now Office of Emergency Preparedness) as to whether imports of a particular article are threatening to impair the national security, followed by a determination by the President of both the relevant facts and of the action he deems necessary to counteract the threat. The statute was further amended by Section 8 of the 1958 Extension Act in several important respects: (1) to require the President to take remedial action upon a report by the OEP Director, "unless the President determines that the article is not being imported" in a manner threatening the national security, (2) to authorize the President "to take such action, and for such time, as he deems necessary" to adjust imports for the purpose, and

(3) to set forth in a new subsection (c) certain standards to be considered; chiefly the impact of imports on "domestic production needed for projected national defense requirements" and on the "capacity of the U.S. to meet national security requirements," as well as the "impact of foreign competition on the economic welfare of individual domestic industries" so as to determine "whether such weakening of our internal economy may (itself) impair the national security." As so amended, the statutory provisions were incorporated without substantive change into the Trade Expansion Act of 1962 as Section 232.

The stated purpose of the Oil Import Program is to protect the national security by restricting imports from foreign sources, thus insuring a stable, healthy industry in the United States capable of exploring for and developing new hemisphere reserves to replace those being depleted.

The limiting of imports of oil into the United States basically is a problem of balancing a sufficient level of imports with domestic production without depressing or eliminating domestic crude oil exploration, development, and production efforts. It generally is agreed that, were the oil import program to be substantially relaxed or abolished, imports presumably would increase, the domestic price of oil over the short term would fall (perhaps to the price of imported oil if controls were abandoned entirely), short-term

foreign crude prices might rise, and marginal, domestic production would be forced out of production. Further, domestic exploration and development incentives would be reduced resulting in a decline in the development of new domestic oil and gas resources.

(2) <u>Present Operation of the Oil Import Program</u>

On February 20, 1970, the President established the present Oil Policy Committee. He directed at that time that:

> "While most day-to-day administrative functions will continue to be performed by the Oil Import Administration (now Office of Oil and Gas) of the Department of the Interior, the policy, direction, coordination, and surveillance of the program will be provided by the Director of the Office of Emergency Preparedness, acting with the advice of this permanent Oil Policy Committee."

The Committee is composed of the Director of the Office of Emergency Preparedness (Chairman), the Secretaries of State, Treasury, Defense, Interior and Commerce, the Attorney General and the Chairman of the Council of Economic Advisors. The Chairman of the Oil Policy Committee makes his oil import recommendations to the President. Upon acceptance, the President then issues such policy in the form of a proclamation. Oil Import Regulations are promulgated by the Secretary of the Interior with the concurrence of the Director, Office of Emergency Preparedness.

Presidential Proclamation 3279 (17), as amended, restricts petroleum imports into the United States by product (commodity), geographical area in the United States and, in some instances, country of origin.

Allocations of imports of crude oil, unfinished oils, or finished products are made for a period of 1 year--that is, January 1 through December 31, except that allocations of imports into Petroleum Administration for Defense (PAD) District I of residual fuel oil to be used as fuel and allocations of crude and unfinished oils in Puerto Rico are made on an annual basis beginning April 1.

Prior to the beginning of each allocation period, the Administrator of the Oil Import Administration determines the quantities of imports of crude oil, unfinished oil, and finished products which are available for allocation in Districts I through IV, District V, and in Puerto Rico respectively. He also determines the quantities of imports of residual fuel oil to be used as fuel in Districts I and V. The Secretary of the Interior may review the level of imports of residual fuel oil to be used, making such adjustments as he determines to be consonant with the objectives of the proclamation.

Applications for allocations of imports of crude oil, unfinished oils, or finished products and for a license or licenses must be filed with the Director, Office of Oil and Gas not later than 60 calendar days prior to the beginning of the allocation period for which the

allocation is required. Allocations of crude oil and unfinished oils are made to petrochemical firms and to oil refiners. Refinery allocations are made relative to the refinery inputs of the prior 12-month period during September 30. A sliding scale is used to give preference to small refiners.

Allocations and levels for the importation of petroleum are published annually for Petroleum Administration Districts I-IV (States East of the Rocky Mountains), District V (West Coast States, plus Alaska and Hawaii) and Puerto Rico. For purposes of import controls, petroleum imports are generally categorized as crude, unfinished oils, finished products, No. 2 fuel oil, asphalt, and residual fuel oil.

Product imports are almost negligible, except for the importation of 45,000 B/D of No. 2 fuel oil and unrestricted but licensed quantities of residual fuel from overseas sources into District I (the East Coast States plus Vermont and West Virginia), asphalt into Districts I-IV, and finished products manufactured from Canada crude and imported over-land from Canada into Districts I-IV. Imports of other products such as gasoline have been intentionally discouraged to minimize the "exportation" of refining capacity.

Special arrangements are made for imports into Puerto Rico, and for shipments of relatively small quantities of products from Puerto Rico (64,000 barrels per day) and imports from the Virgin Islands (15,000 barrels per day) to the mainland.

Imported unfinished oils (15 percent of the license in District I-IV and 25 percent in District V), as well as crude imports are further processed upon entry into the U.S. These oils are imported primarily by refiners, although some licenses are granted to petrochemical producers.

Allocations to refiners are made according to a sliding scale based on refinery inputs. Petrochemical allocations are computed as a percentage of inputs (11.2 percent in Districts I-IV and 11.9 percent in District V).

The level for imports into District V is computed as the amount required to supplement shipments from other PAD Districts, estimated domestic crude production, and overland imports from Canada so as to meet estimated demand in District V. The level for imports into Districts I-IV other than residual fuel and certain products which enter without restriction (Canadian NGL, Western Hemisphere LPG), was calculated as a percentage of estimated domestic consumption during the early years of the Mandatory Oil Import Program. At the

present time, the quota is computed as 12.2 percent of estimated domestic production in Districts I-IV, plus annual increments of the magnitude recommended by the minority Report of the Cabinet Task Force on Oil Import Control. Although the modified 12.2 percent formula remains the official basis for computing the quota, the annual increment is now based on a comparison of projected supply and demand. On May 11, 1972, the President issued a proclamation raising oil import quotas in Districts I-IV by 230,000 barrels a day. The Canadian quota was raised 30,000 barrels per day while the offshore quota was raised by 200,000 barrels. This represents an overall increase of about 15 percent. The quota for Districts I-IV may be allowed to expand further as increases in demand continues to outstrip domestic production capacity.

(3) International Uncertainties

In considering the modification or elimination of the Mandatory Oil Import Program as an alternative to the production of oil and gas from the proposal, a particular concern is the security of Middle East supply sources which have been characterized by instability and international tension. The supplies of oil from that area may be subject to interruption for political or economic reasons with little or no advance warning. In their comments relative to the Department of the Interior's analysis of the Economic and Security Aspects of theTrans-Alaska Pipeline, the Secretaries of State and Defense and the Director of the Office of Emergency Preparedness indicated their concern that "failure to obtain desired additional oil supplies (from the North Slope) will necessitate increasing imports from

insecure sources to such high levels that a long-term foreign supply disruption could slow down industry and imperil our national security".

A systematic treatment of the oil import subject is contained in the report of the Cabinet Task Force on Oil Import Control, (The Oil Import Question, 1970). While the task force disagreed over preferences for tariffs over the percent quota system as the basic method of restricting imports, there was concurrence that imports from the Eastern Hemisphere should be limited. Such a limitation would require some type of continuing import controls.

The Oil Import Question identified eight major difficulties that might attend dependence on foreign supplies:

(1) War might possibly increase our petroleum requirements beyond the ability or willingness of foreign sources to supply us.

(2) In a prolonged conventional war, the enemy might sink the tankers needed to import oil or to carry it to market from domestic production sources such as Alaska.

(3) Local or regional revolution, hostilities, or guerilla activities might physically interrupt foreign production or transportation.

(4) Exporting countries might be taken over by radical governments unwilling to do business with us or our allies.

(5) Communist countries might induce exporting countries to deny their oil to the West.

(6) A group of exporting countries might act in concert to deny their oil to us, as occured briefly in the wake of the 1967 Arab-Israelis War.

(7) Exporting countries might take over the assets of American or European companies.

(8) Exporting countries might form an effective cartel raising oil prices substantially.

A subsequent study made by the Petroleum Industry Research Foundation reexamined the principal assumptions and conclusions of the Task Force regarding U.S. dependency on oil imports in 1980 under various price assumptions, (Oil Imports and the National Interest, 1971).

This study raised questions relative to an indicated overstatement of both U.S. production and Western Hemisphere imports and an understatement of demand for imports from the Eastern Hemisphere which in turn raised further questions as to the extent to which the United States should depend on Middle Eastern and North American petroleum sources.

A Joint Economic Committee Background Study relative to the April 15, 1971, OEP Report on price increases in crude oil and gasoline raised numerous questions relative to the need for, and effectiveness of, the Mandatory Oil Import Program. 1/

The security problem has two principal parts: a question of military security, and a question of economic security. Both advocates and critics of the Oil Import Program have tended to focus principally on the economic security issue.

The crux of the argument against importing a substantial fraction of the nation's oil is that the sources of additional foreign oil -- in general, the Middle East, and North Africa -- are "insecure", and might withhold oil exports to the United States for political and/or economic gain.

A study of Drs. Schurr and Homan for Resources for the Future 2/ notes

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1/ U.S. Congress, Joint Economic Committee, Report on Crude Oil and Gasoline Price Increases of November 1970, a Background Study; November 3, 1971.

2/ Sam H. Shurr and Paul T. Homan, et.al., Middle Eastern Oil and the Western World: Prospects and Problems. New York, American Elsevier, 1971.

that the question of supply interruptions:

> ". . . needs to be dealt with in the interests of both the importing and exporting countries because supply interruptions are economically damaging to both. Not only do they have sharp short-run effects which are economically painful, but their longer-run consequences can also be damaging if channels of commerce are diverted into alternatives which impose a permanent economic penalty upon both those countries that sell oil and those that buy."

However, this interdependence does not guarantee that interruption will not occur. The study points to interruptions from the shutdown of Iranian production beginning in 1951, the closure of the Suez Canal and attendant lengthening of transportation routes in 1956-1957 and again from 1967 to the present, and quotes Walter Levy, a leading international oil authority and consultant, as saying:

> "Nor can the West rely on the importance of uninterrupted oil operations and oil revenues to Middle East governments as a deterrent to hostile actions. Economic considerations, important as they are to the relatively impoverished countries of the area, become insignificant when confronted with political pretentions."

Eleven major oil producing countries have joined the Organization of Petroleum Exporting Countries (OPEC), in an attempt to obtain greater bargaining power in their dealings with the international oil companies.

A five-year agreement reached in 1971 with the Persian Gulf countries provides for substantial increases in the payments to the host governments. The other members followed with equal or larger increases. In the second year of the agreement, the OPEC countries have been given further increases to compensate for the de-valuation of the dollar, and are demanding participation as part owners in the oil companies exploiting their resources. If OPEC can maintain cohesiveness in the face of diverse national demands and historical relationships, continuing pressure for economic and political concessions by the oil-importing countries may be anticipated.

Projections of the sources of future U.S. oil imports generally assume that Canadian and other Western Hemisphere oil will be imported to the extent to which it is available and that remaining import needs will of necessity be met from the Eastern Hemisphere.

Projections of potential contributions from Canada and other Western Hemisphere nations are shown in the following table. Additional imports from Canada will require substantial additional discoveries and further development of the tar sands industry in that country. However, tar sands do not appear to be price competitive at present. Canada's ability and willingness to maintain and increase its exports depends on its ability to satisfy domestic demands, to increase production, and to find sufficiently stable and attractive markets.

Projections of Imports From Canada and Other Western Hemisphere Sources (million barrels per day)

Import Source	Data Source	1965	1970	1975	1980	1985
Canada	Schurr 1/	0.41	----	0.78	0.95	--
	N.P.C. 2/	--	--	--	--	1.90
	Draft EIS 3/	--	0.70	1.10	1.60	2.20
	Bu. Mines 7/	--	0.76	--	--	1.64
	Syncrude 8/	--	--	--	1.63	--
Other West. Hem.	Schurr	1.66	--	2.46	2.82	--
	N.P.C.	--	--	--	--	1.80 4/
	Draft EIS	--	2.20	2.90	3.25	3.50
Total West. Hem.	Schurr	2.07	--	3.24	3.77	--
	N.P.C.	--	--	--	--	3.70
	Draft EIS	--	2.90	4.00	4.85	5.70
Minimum Estimate	Canada	--	--	--	0.95	1.64
	Other W.H.	--	--	--	2.00 5/	1.80
	Total 6/	--	--	--	2.95	3.44
Maximum Estimate	Canada	--	--	--	1.63	2.20
	Other W.H.	--	--	--	3.25	3.50
	Total	--	--	--	4.85	5.70

1/ Schurr, Sam H., Paul T. Homan, et. al., Middle Eastern Oil and the Western World: Prospects and Problems, New York, American Elsevier, 1971, p. 28. Schurr gives imports in four categories; Middle East, North Africa, Caribbean, and "Other"; the asumption that "other" represents Canada appears consistent with other projections.

2/ National Petroleum Council, "U.S. Energy Outlook: An Initial Appraisal, 1971-1985," Vol. 1, July 15, 1971, pp. 26, 28.

3/ Draft Environmental Impact Statement for the Trans-Alaska Pipeline, prepared by Department of the Interior, January 1971, p. 185.

4/ Assuming all Latin American excess capacity reaches the United States: see National Petroleum Council, p. 28.

5/ Assumed for present purposes, based on the NPC argument that total for 1985 would be 1.80 million bbl/day

6/ Obtained by adding mini. (max.) values for Canada and other West. Hem.

7/ Appendix L, part 3, Vol. II of USDI, "An Analysis of the Economic and Security . . ."

8/ Syncrude Submission, exhibit 2, to Proceedings concerning Application No. 5899 to Albert Energy Resources Conservation Board, September 21, 1971.

The contributions of other western hemisphere nations will be determined by their attitude toward their oil industries (which, though largely owned by the international oil companies, are subject to local government regulations and, occasionally, expropriation), by patterns of domestic demand, export markets in other areas, financial status, and development preferences, so that the projections of export potentials to the U.S. are conjectural.

Although the projections show substantial increases in imports from South America and the Caribbean ("Other Western Hemisphere"), other sources cite declining reserve-to-production ratios in Venezuela and the 6.4 percent annual growth in Latin America demand as evidence that demand in South America will more than absorb any increases in production. 1/ Recent discoveries in Ecuador, though still in the preliminary stage, may yield at least one million barrels per day by the late 1970's. 2/

The following table compares the projected U.S. oil imports from the Western Hemisphere with the overall U.S. crude oil deficits to derive probable levels of imports that would be provided from the Eastern Hemisphere. 3/ It should be noted that if all controls on imports were abandoned, the U.S. deficit would be much higher.

1/ Alberta Energy Resources Conservation Board, Proceedings Concerning Application No. 5849, September, 1971.

2/ Oil and Gas Journal, February 8, 1971, pp. 24-26.

3/ USDI, "An Analysis of the Economic and Security Aspects of the Trans-Alaska Pipeline," Vols. I and II, and Supplement, 1971.

RANGE OF PROJECTED DEPENDENCE ON EASTERN HEMISPHERE
1980 and 1985
(million barrels per day) (percent of demand)

Year	Contribution of Western Hemisphere	Domestic Deficit Estimate		
		Low (8.1)	Medium (11.6)	High (16.2)
1980	Low (2.95)	5.15 (26%)	8.65 (39%)	13.25 (53%)
	High (4.85)	3.25 (16%)	6.75 (31%)	11.35 (45%)
		Domestic Deficit Estimate		
		Low (11.1)	Medium (16.6)	High (22.2)
1985	Low (3.44)	7.66 (33%)	13.16 (49%)	18.76 (61%)
	High (5.70)	5.40 (23%)	10.90 (40%)	16.50 (53%)

It has been argued that the national security objectives of the oil import program could be met in other ways. Generally, these alternatives are means of coping with an interruption of supplies. They include drawing down oil stocks (which depend on storage capacity); expanding production from remaining sources (with varying incremental volume, cost, and time lag); and reducing demand by rationing (of varying formality and intensity). Such measures are alternatives to the oil import program, not to production from the proposal.

b. <u>Incremental Production</u>

The analysis of the previous section indicates that incremental oil imports, alternative to the oil and gas which could be produced by the proposal would be obtained from the Eastern Hemisphere, most probably from the Middle East.

The expected range of production by 1975 is 500,000 barrels of crude and 2.5 billion cubic feet of gas a day. Under the assumption that gas would be exported overland from Canada to the full extent consistent with Canadian energy policy and in view of LNG potential discussed elsewhere in this statement, it is probable that gas production foregone from the proposal would be replaced by imports of oil rather than gas. As the crude oil equivalent of expected gas production would be 445,000 barrels a day, incremental imports alternative to the lease sale would total 945,000 barrels a day.

Thought there were no prospects in Oregon

As noted previously, oil import levels will be significantly higher by 1980 than they are currently whether or not the proposed lease sale is conducted. On the other hand, refinery capacities on the East Coast will be constrained by siting and port limitations and environmental constraints. It is most unlikely that refineries in the East Coast area will have capacities enough to refine as much as half of the area's petroleum requirements, about the relationship between refinery capacity and market requirements which prevailed prior to the Oil Import Program. Under these conditions, all incremental oil imports would be delivered to Gulf Coast ports. It is more difficult to anticipate the distribution of products refined from the crude

oil imported to replace gas production. It is not improbable that such products would be used largely for fuel in the Gulf-coast area, freeing commensurate volumes of gas for pipeline transmission.

c. Technological Feasibility of Substitution

There are no technological restraints associated with the use of increased imports as an alternative to that production expected from the proposal. However, increased reliance upon foreign imports of oil and gas would only aggravate the current disparity in the nation's balance of trade (a $3 billion deficit last year).

d. Environmental Impact

The consideration of environmental impacts in this analysis primarily relates to additional ship traffic and oil handling associated with vessels and related handling facilities required for increased oil imports.

Other detrimental environmental effects of increased oil imports are related to the substitution of oil for gas. Since natural gas combustion emits a lower level of particulate and sulphur dioxide pollution, the replacement of the 2.5 billion cu. ft. per day would cause a deterioration in air quality.

(i) Increase in Ship Traffic

This analysis estimates that one medium sized tanker (world standards) of 120,000 DWT size will be required every day to deliver oil to PAD I (New York) to supply oil equivalent to the oil and gas that would be produced by the proposal. It is assumed that the East Coast will have the facilities to accommodate this size tanker.

Any development of ballast treatment facilities would be accomplished at the loading end of the system and is discussed in paragraph (iv) below. It may be assumed that all intentionally discharged oil in U.S. waters from this alternative will come from tank cleaning operations. why?

To assess fully the impact of tank cleaning operations, three separate analyses are necessary; one assuming uncontrolled operations, one assuming load-on-top (LOT) operations, and one assuming compliance with IMCO standards proposed in the 1969 amendments to the International Convention for the Prevention of Pollution of the Sea by Oil, 1954.

(b) Accidental Discharges

The 1970 Pollution Incident Reporting Systems (PIRS) data indicate that approximately 0.00015% of the oil handled in the U. S. was spilled during transfer operations. 1/ Applying these figures to the indicated throughput of imported oil, the average volume and number of spills during transfer operations in the New York area would be approximately 1.4 barrels per day.

In the restricted waters surrounding harbors and ports the 1970 experience indicates that about 0.00009 percent of the oil handled is accidentally discharged. 2/ For the New York area, this would amount to 0.9 barrels per day spilled.

1/ U.S. Coast Guard, "Marine Transport Systems of the Trans-Alaska Pipeline System", 1972.

2/ Ibid.

(c) Casualty Analysis

The worldwide tanker casualty analysis indicates that 0.0192% of the oil transported is spilled, exclusive to transfer operations. Applied to the 945,000 barrels per day throughput, this amounts to approximately 181 barrels per day discharged from casualties. 1/

However, it must be recognized that an average calculation such as this has little meaning from an environmental impact standpoint. Such impact could be nominal where small spills are involved or where the spill occurs in such a manner as to have little impact on coastal or restricted water areas. By contrast, a single catastrophic incident such as the breakup of the Torrey Canyon can have disastrous results. The oil spill problem is a subject involving considerable study effort. The first report of the President's Panel on Oil Spills 2/ presents considerable details relative to the subject.

(ii) Terminal Requirements

On the basis of the requirement of one additional tanker visit to the New York area (120,000 DWT size) every day or an increase in ship traffic of 6% in 1980, we estimate that no additional terminal facilities would be required to handle the imports necessary to offset oil production from the proposal.

1/ USID, Trans-Alaska Pipeline System, op.cit.

2/ President's Panel on Oil Spills, The Oil Spill Problem, Executive Office of the President, Office of Science and Technology, First Report, 1969.

Daily ship traffic of ships over 100 gross tons has been estimated for New York at 97 in 1972 and 95 in 1980. An increase of approximately 670,000 barrels per day has been estimated to result in an additional 5 percent increase in ship traffic at New York. 1/ At this rate, increased daily ship traffic in the New York area as a result of importing the amount of oil included in this analysis would be approximately 6% (average).

Because nearly 75% of all tanker arrivals in the U.S. occur between Virginia and Maine (most are in New York, New Jersey, and Connecticut), the East Coast is particularly susceptible to tanker pollution. It is estimated that tanker ballasting, loading, unloading, and accidents release about 4 million tons of hydrocarbon pollutants annually into world oceans. To the extent that it would make more tanker traffic unnecessary, the proposal presents environmental advantages over increased oil imports.

Three factors are considered in analyzing possible oil pollution as a result of increased imports: (a) intentional discharge, (b) accidental discharge and (c) casualty analysis.

(a) Intentional Discharge

The two primary sources of intentionally discharged oil are shoreside ballast treatment facilities and underway tank cleaning operations.3/

Where is b & c.

1/ Data from "A Study of Maritime Mobile Satellites" Vol. I "Merchant Vessel Population/Distribution Present and Forecast" prepared by Automated Marine International, Newport Beach, California.

2/ Blumer, Max, "Oil Pollution of the Sea", Oil on the Sea, David P. Hoult (ed.), Plenum Press, New York, 1969.

3/ USDI, Trans-Alaska Pipeline System, Environmental Impact Statement op. cit.

(iii) Off-Loading Facilities

We assume that off-loading facilities presently in place would be used to service imports in this analysis. Oil would be moved from the terminal facilities to refineries by way of existing pipelines. Environmental risks from these opeations would be those attendant to normal pipeline operations, e. g., pipeline leaks and more importantly, breaks from construction, anchor dragging, etc. These risks can be minimized by clearly designating pipeline locations and by the use of automatic shutdown equipment that would detect any sudden drop in pressure or discrepancy in totalizers 1/ on the line to first shut off pumping equipment and then automatically closing sectionalized valves to minimize the quantity of oil released.

(iv) Pollution Potential at Loading Site

This alternative would result in increased potential pollution at the loading end (foreign ports) where pollution control standards may not be as stringent as United States standards; therefore, this alternative would result in a potential net increase in pollution on a world-wide basis.

e. Health and Safety

Increasing imports as an alternative to that production expected from the proposal can be expected to increase industry accidents in direct ratio to the increased ship traffic.

1/ Difference in amount leaving platform and amount arriving at onshore facility.

2. Increase Onshore Oil and Gas Production

a. Description of the Alternative

This alternative would require increased exploration, development and production of oil and gas from the Alaskan North Slope or from onshore sources in the lower 48 states other than Federal lands. in [illegible] Increasing production in the lower 48 states becomes a meaningful alternative only after positive steps have been taken to maintain present producing rates. Consideration must be given to the current low exploratory and discovery rates, high production levels and continuing declines in reserves and producing capacity. The time required to explore for and develop hydrocarbon production is also relevant as trends in exploration and discovery cannot be easily and quickly reversed. Development of North Slope resources cannot occur prior to the establishment of a transportation system.

Domestic development of oil and gas resource occurred initially onshore; offshore development is relatively recent but an increasing portion of domestic production is now coming ~~forth~~ from ~~the~~ offshore areas. In 1971, 12.03% of the domestic U.S. oil supplies and 12.18% of the domestic U.S. gas supplies came from the Gulf of Mexico. These figures can be compared with the OCS contribution in 1960 of 1.93% of oil supplies and 2.14% of gas supplies. This increasing offshore contribution to domestic production is particularly significant when viewed in terms of remaining resources onshore and the changing relationship between offshore and onshore potential.

Proved reserves offshore total less than 5 billion barrels of oil and less than 40 trillion cubic feet (tcf) of gas compared with 33 billion barrels and 240 tcf onshore. (Onshore reserves include 9.6 billion barrels and 26.0 tcf on the North Slope of Alaska) In terms of "indicated reserves plus undiscovered resources producible with current economics and technology, "however, on and off-shore potentials are more nearly equal - 171 billion barrels and 840 tcf offshore and 246 billion barrels and 1,260 tcf onshore. 1/

Potential onshore reserves, even excepting the North Slope of Alaska, could be adequate to meet projected demands but recent drilling efforts have not resulted in discoveries sufficient even to offset current production.

Proved crude oil reserves in onshore areas of the lower 48 states have declined by approximately three billion barrels within the period 1967-1971 even though recovery efficiencies have increased. During the period 1964-1971, a cumulative demand for natural gas totaled 152 tcf or 19 tcf a year, whereas reserve additions only equalled 16 tcf a year. The ratio of reserves to production has fallen to about 8.9 for oil and 11.3 for gas.

1/ USDI, United States Energy: A Summary Review, pp. 22 and 27.

Onshore geophysical work, leasing and drilling efforts have declined during the past decade. A number of factors, all adding up to insufficient economic attractiveness of onshore oil and gas ventures have been cited for the decline. Probably the most significant of all, is the increasing difficulty and cost experience by the industry in finding new oil and gas reservoirs sufficiently large to permit economic production. Only 30 new field exploratory wells were needed to find a significant field in the late 1940's; the number of wells required had nearly doubled by 1960 and this trend has not been reversed.

The importance of finding large fields becomes apparent when it is noted that, in 1970, 63 percent of U.S. production was from only 264 of over 35,000 oil fields in the United States.

The fact of the matter is that the onshore areas of the lower 48 states are mature producing areas where the most likely and easiest to find and develop oil and gas prospects have already been "picked over". Most remaining large fields will be more difficult and costly to find unless geologic techniques capable of identifying stratigraphic traps can be developed. Substantially improved economic incentives will be needed to bring these, as well as smaller fields into production. Additional production could be obtained from onshore sources by expanded application of stimulated recovery methods in existing or new wells. These methods are discussed in a separate section.

b. Incremental Production

The majority of additional production from onshore sources, other than the Naval Petroleum Reserves or the North Slope, will probably be obtained from areas not now deemed competitive. Some increase in the rate of exploration might be expected given a general rise in the prices of oil and gas. A general rise in price, however, would not alter relative economics between producing areas.

Additional production, resulting from increased exploration, will always be associated with a time lag. Periods of at least a year, and in many cases much longer, might be expected depending upon the location and complexity of the new producing area. The expenditures associated with additional exploration and development may be expected to be quite variable. It is reasonable to assume that this additional effort will be reflected in additional costs to the consumer.

North Alaska

The Prudhoe Bay field currently is estimated to contain 24 billion barrels of oil-in-place. At an estimated recovery rate of 40 percent, the current proved recoverable reserves of the field are 9.6 billion barrels of crude oil. 1/ These reserves alone make the Prudhoe Bay

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1/ American Gas Association, American Petroleum Institute, and Canadian Petroleum Institute, Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada and United States Productive Capacity as of December 31, 1970 (May 1971), p. 27.

field the largest ever discovered on the North American continent 1/. Nevertheless, the 9.6 billion barrel estimate may be a conservative indication of the crude oil potential of the field and the Arctic Slope province.

The current reserve estimate for the Prudhoe Bay field is for unextended pools and assumes primary recovery only. With further developmental drilling and application of secondary recovery techniques, it is likely that at least 20 billion barrels of crude oil will eventually be recovered from the Prudhoe Bay field. This would make it the fifth largest oil field ever discovered in the world 2/.

The Prudhoe Bay field has large reserves of natural gas dissolved in or associated with its crude oil reserves. Recoverable gas reserves in the field were estimated to be 26 trillion cubic feet as of the end of 1970 3/. An average of 750 cubic feet of dissolved gas per barrel 4/ for the current oil reserves of 9.6 billion barrels would indicate reserves of approximately 7 trillion cubic feet of dissolved gas and 19 trillion cubic feet of associated gas. These reserves,

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1/ Michel T. Halbouty, A. A. Meyerhoff, R. E. King, R. D. Dott, Sr., H. D. Klemme, and Theodore Shabad, "World's Giant Oil and Gas Fields, Geologic Factors Affecting Their Formation and Basin Classification," in Michel T. Halbouty, ed., Geology of Giant Petroleum Fields, Memoir 14, American Association of Petroleum Geologists (November 1970).

2/ Halbouty, et. al.

3/ Reserves of Crude Oil . . . p. 170

4/ Suggested by the data given in Bureau of Natural Gas, Federal Power Commission, National Gas Supply and Demand: 1971-1990, pp. 98-99.

which, like the crude oil reserves of the Prudhoe Bay field, are subject to extension and revision, constituted 8.9 percent of recoverable U.S. natural gas reserves at the end of 1970 1/. They also make the Prudhoe Bay field the 13th largest gas field ever discovered in the world. 2/

The estimated reserves of the Prudhoe Bay field do not exhaust the oil and gas potential of the Arctic Slope province in Alaska. The Prudhoe Bay field is located in the Colville Basin. Geologically, this basin is classified as an intermediate crustal type (i.e., its underlying crust is intermediate to that beneath continents and that beneath oceans), the basin itself being extracontinental (located on the margin of a continent) and sloping downward into a small ocean basin. Extracontinental, downward warping basins are among the richest sources of oil and gas in the world. Examples of such basins include the Arabian platform and Iranian basin (Persian Gulf), the East Texas basin, and the Tampico embayment (Mexico). Over half of the 119 known oil fields with at least one billion barrels of recoverable reserves are found in the 10 known basins of this type 3/.

1/ Reserves of Crude Oil . . . p. 124

2/ National Gas Supply and Demand: 1971-1990, p. 74

3/ Halbouty, et. al.

The ultimate potential on the onshore area in the Arctic Slope province is uncertain. The platform along the Arctic coast gives considerable geologic indications of being very favorable for both oil and gas 1/. Comparison with the history of similar basins indicates a high probability of further discoveries of varying size. Professional estimates of ultimate recovery for the province range from 30 to 50 billion barrels 2/ 3/. Considerably higher estimates than these have been made 4/. but the geologic evidence for them is lacking.

Similarly, the natural gas prospects of the North Slope are not limited to the Prudhoe Bay field. Several gas fields were discovered in the 1940's and 1950's on NPR-4, the largest of which was the Gubik field with 300 billion cubic feet of reserves. Geologic investigations

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1/ George Gryc, "Summary of Potential Petroleum Resources of Region 1 (Alaska and Hawaii) - Alaska," and W. P. Brosge and I. L. Tailleur, "The Northern Alaska Petroleum Province," in Ira H. Cram, etc., Future Petroleum Provinces of the United States - Their Geology and Potential, Volume 1, Memoir 15, American Association of Petroleum Geologists (1971).

2/ Ira H. Cram, "Future Petroleum Provinces of the United States - Their Geology and Potential: Summary" in Cram, ed., Future Petroleum Provinces..., p. 24.

3/ Sam H. Schurr and Paul T. Homan, Middle Eastern Oil and the Western World: Prospects and Problems (New York: American Elsevier, 1971), pp. 86-87. Personal communications with Richard Meyer, Office of Oil and Gas, George Gryc, U.S. Geological Survey, U.S. Department of the Interior.

4/ Governor Egan of Alaska was quoted in The Oil Daily (July 7, 1971), p. 3, with an estimate of 150 to 300 billion barrels.

of other parts of the North Slope have indicated a favorable potential for future gas discoveries within them as well 1/.

Under the Trans-Alaska Pipeline proposal, all of the North Slope oil to be transported by that line would be delivered to the West Coast (PAD V) within the first few years after full operation. Therefore, oil from that source cannot be considered an alternative for production to be consumed outside PAD V. Deliveries of oil from other fields and by other transportation facilities are too remote and too conjectural for meaningful consideration in current planning.

Given the large size of the Arctic gas reserves and the projected shortages in other sources of domestic supply, there is high probability that this gas will be developed. Three different consortia have made proposals for gas pipelines down the Mackenzie Valley to these potential markets. However, many major uncertainties remain; for example, at this time industry experts differ in their opinions about how soon the gas caps in the Prudhoe Bay field can be tapped. Assuming 750 cubic feet of dissolved gas per barrel of oil produced, only 1.5 billion cubic feet per day of dissolved gas would be produced when oil production reaches a level of 2.0 million barrels

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1/ See "The Northern Alaska Petroleum Province."

per day. The additional gas required to meet the full planned pipeline capacity would have to come from the gas caps. The issue may not be fully resolved until several years after oil production begins, at which time empirical data on the effects of production of associated gas on the production of oil will be available. It is likely that a gas pipeline to the Midwest and lower Canada will ultimately transport gas from both the North Slope and the Mackenzie Delta region.

c. Technological-Feasibility of Substitution

In general, maintaining and increasing the rate of onshore exploration and development for oil and gas will require new technologies in exploration and recovery. The incremental technology needed as an alternative to the volume of production anticipated from Federal lands would be the same as that required for additional production from these lands. Problems relating to substitution of energy forms would not arise.

d. Environmental Impact - Lower 48 States

(i) Impact on Air Quality

The impact of additional petroleum production on air quality stems principally from the emission of particulates into the atmosphere; however, some disturbance results from noise and vibrations.

why not refer to section IV of report.

Particulates

Engine exhausts from boats, vehicles and stationary engines result in emission of the products of combustion that pollute the air. The impact of this pollution from the level of activity normally associated with increases in petroleum production is dependent upon climatic conditions, topography, and localized conditions. Air quality in immediate areas will undergo some reduction because of removal of ground cover operations, dust from vehicle traffic, and from occasional equipment failure or blowouts. Such quality reduction is generally of a temporary nature and has a short-term effect.

Vapor venting from storage tanks and vessels, the burning of waste petroleum and chemical products, especially those containing some sulphur compounds, could result in increases of particulates into the atmosphere and objectionable odors. These impacts on the environment are also of a short-term nature.

Noise and Vibrations

Noise and vibrations from stationary engines used in drilling and production operations and transporting systems disturb the natural environment. The impact exists only for the time-frame that the engines are in use and are local in nature.

Effects of Air Quality Reduction

It is highly unlikely that air quality reductions from operations associated with increased petroleum production would significantly alter conditions affecting the growth of flora. The feeding and nesting habits of birds and animals, wilderness qualities and hunting could be altered as a result of noise and vibrations associated with increased petroleum operating. After termination of operations, a reversion toward original conditions would be expected.

Impact on Land Quality

The modification of land form necessary for petroleum production results in varying degrees of environmental impacts on the physical and chemical land characteristics, biological conditions, cultural factors, and ecological relationships.

Depending upon the terrain and local conditions, access to the land is normally from existing road networks, extension of these roads, and expansion of trails. For initial exploratory work, minimum alterations are made in roadway systems. After decisions are made to drill in a given area, an improved road system is required for the transportation of heavy loads. The drilling site must be cleared of vegetation which might present obstacles. Once production has been

established, newly constructed roads are normally improved. From these operations environmental impact can result from removal of top soil and surface vegetation to establish right-of-way corridors and location sites, and alteration of drainage patterns and watershed cover.

In the construction of roadways, surface vegetation is removed and drainage patterns are modified. As a result, erosion can occur resulting in changes in landform. Trees, shrubs, grass, and crops may also be subjected to indirect effects by modification of drainage patterns. Although nature attempts to repair environmental degradation, external help may be required. Soil erosion and siltation can have both direct and indirect impacts upon the normal behavior and activity patterns of wildlife. Small animals and birds may not be significantly affected, although their number in the immediate vicinity of the operations might decrease in proportion to disturbances and lost habitats. The habitat may be altered beyond the life of the producing and transporting operations.

Land use and recreation activities may also be disrupted during drilling, producing and transportation operations. Aesthetic and human interest factors are affected for time-frames beyond the terminations of operations. Scenic views and vistas, wilderness qualities, and physical features in some localities could undergo

alterations that could be considered permanent transformations. Population density, employment, and cultural life-styles would change from drilling, production, and transportation levels. The change would be of long-term impact and directly affect access, utility networks, waste disposal, and creation of additional corridors. These effects would not necessarily be adverse.

While the construction of pipeline facilities has the potential for causing unfavorable environmental effects, the employment of good construction techniques can minimize or even eliminate most of these effects. Farming or grazing lands can usually be restored to their original condition after no more than one growing season by the replacement of top soil and the replanting of grass or crops. The aesthetics of wilderness areas can be preserved by using existing rights-of-way or minimizing the width of new rights-of-way, by replacing grass and shrubs on the rights-of-way, and by using such techniques as feathering and screening or deflecting entranceways. Any displacement of wild animals will occur only during the construction. Banks can and should be stabilized to avoid erosion during construction. Access and service roads should be maintained with proper cover, water bars and appropriate slope to avoid soil erosion. Compressor stations and other above ground facilities can be located in unobtrusive sites and planted with appropriate trees and shrubs to enhance their appearance; location, planting

and exhaust design can be used to abate excessive noise associated with operation of the compressor stations. Treatment plants can be located and equipped with devices to minimize any adverse effects upon air quality and suitable means; e.g., evaporation ponds or disposal wells, can be found for preserving the water quality of the surrounding area.

A potential source of land pollution is a blowout during drilling but the frequency of blowouts is small. One hundred and six blowouts occurred in drilling 273,000 wells in 8 major oil producing states from 1960 through 1970. Most blowouts are from high pressure gas rather than oil. Other pollutants from blowouts are drilling mud and salt water. 1/

Impact on Water Quality

Access to Area

The contruction of roads for access into prospective petroleum producing areas could affect water quality in that drainage patterns are disturbed and some erosion is possible. The dredging of canals could result in increased turbidity and resuspension of bottom sediments as well as salt water intrusion.

1/ Environmental Conservation, The Oil and Gas Industries, Volume 1, June 1971, National Petroleum Council, p. 63.

Production Operations

Entry of foreign substances such as oil, chemicals, brine, and waste materials into the water cycle is one of the major environmental risks associated with petroleum production operations. Spills or leaks allowing oil, brine, and waste substances to enter the water cycle can result from human error, corrosion of pipelines and vessels, ruptures or mechanical failures, burning pits, open ditches and blowouts.

During production, large amounts of salt water may be produced as oil fields age. Such water can create pollution problems from producing wells on land or freshwater-covered areas. According to a study of the Interstate Oil Compact Commission (IOCC), up to 25 million barrels of salt water are produced daily from the Nation's oil wells. Proper disposal of produced brines has been and continues to be of major concern to producing operators, and regulatory agencies. Subsurface disposal is strictly regulated by some state conservation agencies and disposal of salt water is not permitted in freshwater streams. 1/

Effects of Water Quality Reduction

Removal of vegetation, changes in drainage patterns, and erosion

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1/ National Petroleum Council, Environmental Conservation, The Oil and Gas Industries, Vol. II, 1972, p. 147.

results in turbidity and siltation which reduce the water quality of reservoirs and estuaries. Turbidity is considered to be of short-term duration but may affect local flora and fauna. Siltation of water reservoirs and estuaries has long-range environmental impacts in that the shape and size of the water basin is altered. This can have an adverse impact on flora, recreation activities, aesthetic qualities and perhaps disturb ecological food chain relationships.

The reduction of water quality and its attendant consequences through the introduction of oil, chemicals, brine, and waste materials into the water cycle ranks as a major environmental risk. The introduction of oil or brine into the water cycle can result in adverse conditions affecting trees, shrubs, grass, crops, and aquatic plants, birds, land animals, and fish. Sheltered lagoons and estuaries impose natural dispersal restrictions on oil spills causing the oil to remain trapped or concentrated in such areas for long periods. Consequently, in some localities, this adverse effect could be long-term. Generally, the degree of reduction in water quality will determine the duration of environmental impact. Major reductions in water quality that significantly disrupt the food chains in bays, lagoons, and estuaries could have long-term environmental effects.

Impact of Operations

Perhaps the greatest adverse environmental impact from operations results from oil, chemicals, brine, or waste material pollution. This pollution can result from spills, leaks, blowouts, human errors, or equipment failure. Although care is exercised to prevent land pollution, there are no fail-safe methods to completely protect the environment.

Land pollution operations, primarily salt water and accidental oil spills, can result in soil sterilization that could be of a long-term nature and affect not only the topsoil but underground water quality. These problems were mentioned earlier. Native vegetation and crops can be adversely affected for short or long-term duration depending upon the volume and toxicity of the pollutant, resistance of the flora, and the techniques and technology employed. Alterations of the flora in turn affect the habitat of birds and animals. Nature has a tendency to overcome the imbalance and in some cases can repair the environmental degradation. Depending upon the degree of pollution, land uses such as agriculture, grazing, forestry, and wilderness can be altered for varying time-frames. In some cases large pollutant concentration could be sufficient to kill vegetation, trees or crops and disrupt wilderness areas for long terms. Recreation in areas subjected to large pollutant concentrations can also be altered for long time-frames.

Depending upon local conditions, aesthetics such as scenic views and vistas, wilderness qualities, unique ecosystems, or historical sites and objects may be altered. The degreee of alterations would be dependent upon the degree of pollutant introduction and local conditions. Ecological relationships such as food chains, salinization of soil, and water resources, could result from pollutant contamination. The degree of contamination has a bearing upon the term of environmental impact.

In exploring and pipelining, any spills that occur normally would be small. Major spills could occur in drilling, production, and in the movement of petroleum liquids by marine transportation. The Federal Water Quality Administration (EPA) estimated that 10,000 oil spills occur a year of which 2,500 are ground spills. 1/ Most ground spills cause little ground pollution. According to the 1970 report of the Office of Pipeline Safety (Department of Transportation) on spill incidents, there was a total of 347 liquid pipeline accidents. In those accidents, spills averaged approximately 1,780 barrels of crude oil. Principal cause of over 50 percent of accidents was corrosion. Many onshore pipelines are old, dating back to 1920's before techniques for protection against corrosion became widely used. Continued accidents can be expected from these lines. With the development and

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1/ National Petroleum Council, Environmental Conservation, op. cit. p. 146.

expanded use of cathodic protection of pipelines, fewer accidents in new lines would be expected, but accidents from old lines will continue to be of concern.

e. Health and Safety

An increase in exploration and development of onshore oil and gas is not expected to affect the health or safety of individuals living within the area of increased operations. Accidents to those working in the industry are expected to occur at historical rates with any increase being in direct relation to the increase in operations.

3. Increased Domestic Outer Continental Slope Production of Petroleum

Discussion of additional domestic production of crude petroleum (and natural gas) must consider production from onshore and also from the continental shelf. A separate discussion follows:

a. Outer Continental Shelf (OCS) Production

This alternative would require increased exploration, development and production of crude oil from offshore areas. Supplies equal to all, or a significant part, of the projected 500,000 barrells daily would have to be developed and produced in addition to those supplies that are projected to be produced from OCS resources under the present leasing schedule during the same time frame.

Even though there is a demonstrated need for development of petroleum resources in offshore areas, development has not progressed to the extent required to meet projected production requirements. In response to the President's June 4, 1971, Clean Energy Message, which called for accelerated OCS leasing, a tentative schedule for leasing oil and gas resources on the OCS setting forth sales through 1975 was published. The schedule proposed an average of two major sales per year, double the previous rate. Both traditional OCS leasing areas in the Gulf of Mexico and virgin areas such as the Atlantic and Alaska OCS are included.

Implementation of the schedule was delayed after the first sale by a court injunction which precluded the completion of the December 1971 general lease sale offshore eastern Louisiana. Although no commitment

to hold a sale off the Atlantic coast has been made, opposition to such a sale already has been voiced.

Assuming that the OCS Lease Sale Schedule is continued at the rate of two sales per year in the Gulf of Mexico, the government might be able to offer sufficient additional favorable acreage to provide an incremental 500,000 barrels per day in 1975 by leasing in frontier areas and beyond 200 meters. Leasing in frontier areas is necessary to obtain the additional production since the Gulf of Mexico alone is not expected to be able to provide the incremental production in addition to the extended leasing rate for that area. It is doubtful, however, that an additional 300,000 barrels per day could be obtained by 1975 from leasing in frontier areas, since it is estimated that lead times up to 12 years will exist between leasing and production in these areas.

Evaluations of discoveries in offshore areas indicate that a drilling effort in excess of 3,000 wells might be required to provide a sufficient number of oil well completions between 1976-1980 to equal the oil that could be provided through the proposed program. An overall mix of completions would indicate approximately 1750 wells must be drilled to provide an equivalent amount of <u>energy</u>; i.e., both oil and gas wells. These wells would be in addition to those that are expected to be drilled to provide supplies to meet projected demands during the same time frame.

Changes that could be beneficial to stimulation of additional development include price increases, subsides, tax benefits, and changes in leasing procedures. The cost and effectiveness of such changes are unknown. The timeliness and the volumes of increased supplies that would result from increased incentives are also unknown. Drilling rig availability might be a major problem. Less than 100 mobil drilling rigs were operating in domestic offshore waters in 1971.

Acceleration of the OCS leasing program to obtain additional production above that expected to come from the current leasing rate in the Gulf of Mexico is doubtful. This production probably will not be obtained during this time period since leasing beyond 200 meters will have international implications which must be considered. Furthermore, opposition has already been expressed against leasing in frontier areas.

(1) Potential Environmental Impacts

The environmental impact discussed below is based on past leasing and production experience in the Gulf of Mexico. Environmental information has not been developed to a similar degree for frontier areas. However, that data is currently being accumulated, and even though it is realized that environmental conditions in these areas differ from currently producing OCS areas, it is believed that the same categories of impacts will be encountered.

The potential environmental impacts that are encountered from Outer Continental Shelf (OCS) leasing and production include impacts on air and water quality, commercial and sport fishing, shipping, recreation and tourism, beach, marsh and estuarine biota, and seaward biota as a result of exploratory surveying, platform (structure) placement, debris, oil spills, waste water disposal, and pipeline construction.

Possible environmental impacts from OCS oil and gas development are covered in detail in a final environmental statement issued by the Bureau of Land Management, U.S. Department of the Interior (28) (herein the OCS Statement).

(a) Exploratory Surveying - The initial effort in OCS exploration involves geophysical or seismic exploration activity. Exploratory seismological surveys leave little, if any, lasting impact

on the environment. The use of explosives as an energy source have been largely discontinued in marine survey operations and less environmentally hazardous methods of generating sound energy, such as compressed air charges or vibrating acoustical systems have been adopted. Therefore, the only adverse impact resulting from exploratory surveys would be minor noise and exhaust emissions normally associated with deisel powered vessels.

(b) Structures - As of August 31, 1972, over 1,893 platforms, including single and multi-well structures, have been installed in OCS Gulf of Mexico waters. Turbidity resulting from the placement of drilling and production platforms involves a small area and is of short duration. Destruction of the benthos is also confined, and only involves a few square feet for each piling.

Since the advent of offshore oil and gas activities many species of fin fish have become concentrated around the drilling structures, which provides an artificial habitat. Among these are: red snappers, groupers, trigger fish, spade fish, giant sea bass, pompano, and many smaller species. There is evidence that these species and other larger seasonal game fish, such as sail and bill fish, have appeared since the offshore oil industry became active. The platforms create unique offshore artificial environments which attract and concentrate many predatory species, providing favorable fishing sites for sportsmen

and commercial snapper fishermen. The long term effects of this intense species concentration, in lieu of the more random distribution patterns, is not known; but natural predator-prey relationships could be affected.

Platforms and drilling rigs in view of land may disturb the scenic views and vistas of coastal inhabitants and tourists and the open space qualities of the seascape. The distance from shore at which a structure can be seen is mainly a function of the height of the structure and visibility. For example, a 100 foot high platform drops below the horizon at 16 miles while a 169 foot high platform disappears at 20 miles. Visibility conditions may also reduce the distance at which a platform may be seen.

Despite the installation of navigational aids the erection of additional platforms on the OCS particularly those adjacent to fairways, are a potential hazard to shipping. Safety fairways have been established to permit safe passage of vessel traffic into and out of ports. Anchorage areas are similarly designated for safety purposes. While exploratory drilling in shipping lanes is permitted with approval by the Corps of Engineers, installation of fixed structures is prohibited under 33 U.S.C. 403 and 43 U.S.C. 1333(f). Production can be initiated by directional drilling from a portion of the tract outside the lane or from adjacent leaseholds outside of fairways. In some cases platforms act as aides to navigation by providing a reference point from which a

ship may find its position. They have also been used as refuges by sport fishermen in rough weather.

Platforms may be obstacles to commercial fishing when fish trawling equipment is used. The noise of drilling rigs, acoustical warning devices, and support vessel traffic operating in rivers, canals, and on the open sea could also be expected to have an effect on the coastal area environment.

(c) Debris - Debris would be those substances which are discharged or thrown into the sea (excluding waste water) as the result of a platform or support operation.

The improper disposal of this debris, (trash, drilling muds, bilge wastes, and spills of crank case oil and engine fuel) characterize other possible kinds of vessel or platform related sources of pollution. Toxic debris, such as paints and thinners, can poison and cause the death of some organisms. Floating non-biodegradable debris is unsightly to tourism and recreational use and poses a hazard to small crafts. Sinking debris can foul and damage commercial fishing nets. It may act as an artificial reef because some biodegradable material may be eaten by some marine organisms. The amount of debris discharged into the environment as a result of OCS operations has been found to be small due to enforcement of pertinent regulations. For an extensive discussion of all types of

debris including regulations and methods of enforcement concerning their discharge see the aforementioned OCS Statement.

(d) Oil Spills - During the period 1964-1971 38 significant recorded oil spills involving 50 bbl. or more of oil and condensate occurred on Federal OCS lands 1/. The estimated total volume of oil spilled as a result of these incidents is slighly less than 300,000 bbl. During this same period, more than 2 billion bbl.. of oil and condensate were produced in the Gulf of Mexico offshore Texas and Louisiana and on the Pacific Coast OCS. The amount of recorded spills represents approximately 0.014% of the oil and condensate produced in the OCS during the same period.

Blowouts during exploratory drilling pose the greatest potential for serious pollution of offshore waters by hydrocarbons and of air quality by fire. Normally, drilling muds and blowout prevention devices (all drilling rigs are equipped with blowout preventers) control the natural pressure in a well; nonetheless, blowouts do occur. From June 9, 1956 to July 18, 1971, 35 blowouts occurred on Federal OCS oil and gas operations 2/. Ten of the 35 blowouts resulted in a total oil or

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1/ All data is taken from a table prepared by Offshore Operations Section, U.S. Geological Survey; "Accidents Connected with Federal Oil and Gas Operations in the Outer Continental Shelf thru 1971."

2/ Ibid.

condensate spillage of 79,680 bbl. Fire occurred on 10 of the 35 blowouts; 8 of the fires burned gas only. During the 15 year period, 10 blowouts resulted in oil or condensate spills into the water and 2 of the 10 blowouts had oil fires which impacted on air quality.

A total of 1,553 oil and gas tracts have been leased in Federal areas of the Gulf of Mexico and California since the inception of the OCS leasing program in 1954. During this time there have been a total of 11 major oil spills (both blowouts and pipeline incidents) of 1,000 bbl. or more connected with these areas. Three of the 11 major spills were the result of pipeline ruptures or leaks and the remaining were the result of accidents which occurred on specific platforms and on specific tracts during operations. Thus there is a ratio of 1 major oil spill per 141 tracts leased, and one major spill resulting from pipeline breaks and ruptures per 518 tracts leased.

Data compiled from the Pollution Incident Reporting System (PIRS) of the U.S. Coast Guard show that in 1970 there were 12 spills attributed to offshore oil wells. Total quantity of oil involved was estimated to be 111,900 bbl. When related to the 589,127,000 bbl. of oil produced in offshore areas, spills attributed to offshore production are extremely small (.0002 percent). There were 23 spills attributed to offshore pipelines with only one of significant size. Twenty-two spills were

estimated to average 5 bbl. per spill. A total of 295 spills were attributed to barges. Average size of the spill was estimated at approximately 66 barrels.

The marine environment is rich in both its variety and number of marine life. Pollution affects, in varying degrees, all forms of marine plant and animal life from those that are lowest in the food chain to those at the top. The precise effects of oil spillage on the marine food chain or food web (which consists of plants, bacteria and small marine organisms) are not well understood because of the wide fluctuations and cycles that occur naturally and are totally independent of the effects of oil (29). The degree of pollution, duration, constituency of the fuel and the physical conditions under which it occurs determine the extent of the impact. After pollution has occurred, a normal balance may be regained in a short period of time, or the impact may be more severe and recovery may require a span of many years. Little is known of what effect the chronic incremental discharge of oil, associated with normal drilling and production operations, may have on the marine food web. In any case, the normal "health" of the ecosystem is disrupted and a balance is lost during the period of recovery.

Pelagic seabirds frequently are the most obvious victims of oil pollution because they are likely to come into direct contact with

the oil. Contamination of oil destroys the waterproof qualities of their plumage, a condition from which they seldom recover, even when careful rehabilitation is attempted. Harm to the birds from contact with oil is reported to be the result of a breaking down of the natural insulating oils and waxes shielding the birds from water with the consequent loss of body heat. The 1969 Santa Barbara oil spill resulted in the known death of 3,686 birds and many marine organisms at the intertidal zone. Efforts to cleanse or rehabilitate contaminated birds have generally been unsuccessful. Less than 20 percent of the treated birds survived the Santa Barbara clean-up attempts. Similarly, bird species are vulnerable if beaches and marshes become contaminated by oil, especially if vegetation and food sources are destroyed. In the northern hemisphere, hundreds of thousands of swimming and diving birds have perished from oil pollution during and since World War II and a marked reduction of some nesting populations of sea birds from such mortality has been documented (31). However, no such problem has been documented in the Gulf of Mexico as a result of oil spills on the OCS.

Equipment and procedures for recovering oil spilled in protected waters are well developed, but similar capability in the open sea is severely limited. There are no recovery devices capable of picking up oil in rough seas with wave levels over five feet. The use of sorbents which

have an affinity for oil pose specific problems: distributing sorbent over the area affected by the oil spill is difficult particularly in high winds; there is no effective procedure for collecting the sorbent after contact with spills; and, treating or disposal of such oil-saturated materials is difficult. The chemical and physical process and potential impacts of sinking oil to the ocean bottom is particularly undesirable in shellfish-producing intertidal areas. The use of dispersants on spills introduces the problem of toxicity of such materials if they are poorly handled or are not properly diluted in the water column (29). An extensive discussion of present oil spill recovery techniques can be found on pages 237 and 249-255 of the OCS Statement.

Marine life may also be affected by efforts to remove the surface oil. Emulsifiers, as well as natural storm action, remove oil from the surface by redistributing it as minute droplets throughout the water column. In this condition, oil is more susceptible to biological and chemical degradation, although in combination with such chemicals, it is usually more toxic. Furthermore, the oil treating chemicals themselves have been found to be more toxic than crude oil in many instances (30).

> "Shellfish appear to be quite vulnerable to the majority of chemical dispersants, and in past oil-spill incidents where heavy dispersant spraying has been conducted in the tidal zone or in shallow areas with restricted circulations, large shellfish kills resulted. Fortunately, the effects

of oil spillage on shellfish appear to be fairly temporary, and even in those situations where high mortalities were observed at the time of the incident, complete recovery of the shellfish population appears to have taken place within a period of 6 months to 2 years." (29, pg. 14.)

Nearshore, estuarine, and coastal environments are adversely affected as a result of oil spills if current and wind conditions are such that the spilled oil is transported shoreward in large amounts. Beaches, water recreation areas and historic sites could be rendered temporarily unusable resulting in a loss of recreational enjoyment and economic benefit to the local populace.

Water sports, such as swimming, diving, spearfishing, underwater photography, fishing for finfish and shellfish, boating, and water skiing would be most directly affected. Other marine-related activities such as beachcombing, shelling, seascape painting, shoreline nature study, camping, and sunbathing would be made much less attracti - for an indeterminate period depending upon the promptness and efficiency of the clean-up effort.

Much more critical in terms of total value is the degradation of estuarine and marsh areas which are vital to the ecology as nursery grounds. A complete discussion of the effects of oil pollution in these areas will not be attempted here 1/, but a few of the salient points will

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1/ For a thorough treatment of this subject see pp. 91-143 of the OCS Statement.

be mentioned. There has been one case when mortality of organisms in the immediate area of a No. 2 fuel oil spill was relatively high (95 percent), and within one year after the spill repopulation was occurring at most of the stations of the study. Larvae of the commercially important species such as oysters, crabs, and shrimp which use marshes and estuaries to feed and grow are also affected by spilled hydrocarbons. Continued research on the impact of oil spills on inshore organisms will provide more definitive answers to the questions of mortality and repopulation by indigenous organisms.

(e) Waste Water - A production element which can contribute to offshore pollution is the disposal of waste water associated with oil production. Although the volume of such waste discharge is relatively small, an increase in offshore oil activity, and the advancing state of depletion of water drive fields will cause waste of this kind to be an important consideration. The oil content of waste water discharged as a result of OCS operations is limited to 50 ppm under OCS Order No. 8.

In Federal areas offshore Louisiana 1,893 structures produce a total of nearly 1 million barrels of oil per day; waste water is discharged from approximately 214 of the structures. Total waste water production is about 420,000 barrels per day; 240,000 barrels are transported to

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shore and 180,000 barrels are discharged into the sea. The largest volume of waste water discharged at a single location is approximately 20,000 barrels per day. The decision to separate, treat, and discharge waste water on the platform or pipe it to shore depends primarily on whether or not space exits on the platform for separating facilities and if pipeline capacity is available. The oil content of waste water discharged in OCS operations in the Gulf of Mexico, which averaged 40.8 ppm in March, 1972 can contribute as much as 7.3 barrels of oil per day to the Gulf of Mexico waters.

During 1971, approximately 16 barrels of oil may have been introduced into the ocean daily, either from minor spills, or waste water discharge. Based on these figures, increased production of 300,000 barrels per day, the projected amount recoverable from oil shale by 1980 could contribute an additional 4 to 9 barrels of oil per day from continuous pollution sources on the OCS in addition to spills from unidentified sources.

There is little research on the effects of waste water dicharge on the environment. To date only two studies have produced diametrically opposite results. One study shows that due to the extreme salinity (between 6.1 and 27.0 percent dissolved salts), and the difference in proportion of salts in waste water and sea water, that where quantities were dumped into a stream the biota was destroyed. When the brine was

diluted measureably by rainfall, the fauna moved back into the area suffering pollution. The other study states that results of brine effluent in a stream had no observable effect at a distance of a few feet from the discharge pipe. The study goes on to state that there may even be a "fertilizing" effect due to the introduction of the brine. These studies are, at best, minimal evidence on which to base a sound judgment of the effect of waste water on the environment.

(f) Pipeline Construction - Pipelines laid offshore are buried (required by BLM administrative procedures for water depth of 200 feet or less) to avoid the danger of being struck or dragged by ship anchors as well as to avoid movement in the event of strong water currents in times of intense storms, such as hurricanes. Approximately 98 percent of the oil and all the natural gas produced offshore is transported to shore by pipeline and the remaining 2 percent is transported by barge. Although well blowouts attract the most attention, spillage of oil due to the rupture of pipelines which transport offshore production to shore terminals can be serious. During the last decade ruptured pipelines caused more pollution than drilling and production operations. From 1967-1971 there were 9 pipeline breaks or leaks of 50 barrels or more connected with OCS oil and gas operations, totalling 174,848 barrels. The largest, a spill of 160,639 barrels of oil caused by a pipeline leak due to anchor dragging occurred on October 15, 1967.

Pipeline construction in marsh areas resulting from OCS operations will cause temporary damage, and disturbance of benthic organisms. Depending upon existing environmental conditions, some of this damage may be permanent. When pipelines are buried in coastal marshes it has been a common practice to dredge canals in which to place them. Such pipeline canals increase the ratio of water to wetlands by physically removing the coastal marshes, by facilitating drainage of freshwater necessary to maintain diluted conditions in the estuaries, and by increasing the rate of salt water intrusion from the more highly saline coastal waters. The dredging and redepositing of the displaced sediment also disturbs the local habitat of aquatic plants and animals. Recent studies (32) indicate that 16.5 square miles of marsh have been destroyed each year in coastal Louisiana by erosion, subsidence, and construction. Most of this destruction is attributable to natural causes, including hurricanes, but it has been estimated that approximately 13% (or 2.15 square miles per year) of annual marsh destruction can be attributed directly to canal dredging operations associated with the oil industry. However, it is estimated that less than 3% of the 16.5 square miles annual land loss is attributable to construction of pipeline canals; some of which serve onshore production and others which serve offshore production.

The adverse effects of pipeline construction may be either short-term or permanent, and may be minor or serious, depending on the methods employed in laying pipelines and their location. These effects can be substantially reduced with adequate planning and by using the most

appropriate construction techniques. Usually bulkheads are placed in canals to prevent saltwater intrusion and to maintain existing drainage and water-exchange routes. To protect oysters, pipelines are usually routed around major oyster reefs, and where shallow estuaries are to be crossed, the canal is usually backfilled, as is often the case with canals through marshlands.

A ditching or jetting operation associated with construction in offshore areas generally causes temporary turbidity of the water in the immediate vicinity and may temporarily disturb fish and other aquatic life during that time. It is possible that the operation may also temporarily damage a portion of any shell fisheries existing in the immediate area.

(g) Summary - Even with the best systems and controls, some oil pollution from OCS leasing will occur. The recently strengthened regulations and operating orders 1/ are as stringent as technology allows at this time. Although increased Federal inspections and the large costs involved in controlling, containing, and cleaning up spilled oil have combined to generate an awareness of the necessity to improve the OCS safety record, no regulation or enforcement can guarantee that there will be no pollution from oil

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1/ National Oil and Hazardous Substances Pollution Contingency Plan, 36 FR 16215, August 20, 1971.

producing operations on the OCS. Natural disasters, equipment failure or human error could occur despite regulations and enforcement procedures. Federal enforcement and regulation procedures, and better equipment and engineering standards, although they cannot guarantee there will be no spillage, have served to reduce the risk of oil spill accidents and pollution incidents resulting from OCS development.

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31. Aldrich, J. W., "Review of the Problems of the Birds Contaminated by Oil and Their Rehabilitation", Resource Publication 87, U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, 1970.

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4. Increased Nuclear Power

The nuclear power alternative has been reviewed and commented on by the Atomic Energy Commission. The text has been considerably revised in accordance with their written and informal comments.

a. Description of the Alternative

Most of the currently operating and planned nuclear plants utilize light water reactors. In such reactors, the heat energy created in nuclear fission is removed by the circulation of water through the fuel core to generate steam to turn turbine generators to produce electricity. Four high-temperature, gas-cooled reactors are also completed or on order. These utilize helium circulating through the fuel core to boil water for steam to turn the turbine generators. These reactors are all of the burner type which utilize less than 2% of the available energy from the uranium which they burn. Breeder types of reactors, which produce more nuclear fuel than they consume, such as the liquid metal fast breeder, are not expected to be available for commercial use until the mid 1980's. Breeder reactors could utilize more than 60% of the total energy from uranium. Thermonuclear fusion reactors are not expected to be a commercial reality much before the year 2000.

Of uranium ore reserves at $8 a pound, about 44% is found in New Mexico, 39% in Wyoming, 4% in Utah, 4% in Colorado, and 4% in Texas, and the remainder is scattered throughout the western United States. Approximately 46% of current production of U_3O_8 comes from New Mexico, 26% from Wyoming, 12% from Colorado, and 7% from Utah.

The use of nuclear power as a commercial electricial energy source is expected to increase considerably in the next 15 years. Installed capacity is currently 12,000 MW. This is projected to increase to 46,000-61,000 MW by 1975, 120-139,000 MW by 1980, and 198,000-286,000 MW by 1985. The variance in these estimates is due partly to licensing delays because of concern over environmental effects.

To date operating experience has been limited to relatively small plants. Almost all of the reactors in operation today are of the thermal type but considerable effort is being directed toward developing fast reactors which utilize more of the energy of the fuel material. Highest priority is now being placed on the development of the liquid metal fast breeder reactor. The first U. S. commercial fast nuclear breeder reactor is to be built near Knoxville, Tennessee. Construction will begin in 1974 and the plant will begin operation about 1979. The $500 million project will be financed by TVA, Commonwealth Edison Company of Chicago, and the AEC. Much work remains to be done to produce plants of high safety, reliability, and availability at reasonable costs.

b. Incremental Production

On the assumption that all of the oil and gas production from the proposed leases would be used to provide fuel for additional oil and gas fired power plants, 36 additional nuclear plants of 1,000 megawatts capacity each would have to be constructed and in operation to replace the 1975 oil and gas production 1/.

The construction and operation of additional nuclear generating plants would require additional mining and milling of uranium ore to supply the fuel elements for these plants. An incremental operating capacity of 36,000 MW by 1985 would require 20,400 tons of U_3O_8 for the first core fuels and 6,000 tons of U_3O_8 for annual reloads without plutonium recycling and 4,800 tons of U_3O_8 with plutonium recycling. At an average ore grade of 0.20 percent U_3O_8, a total ore output of over 9 million tons would be required to supply the uranium for the first core fuels, and an annual output of 2.4 or more million tons would be required for reloads. As most of the known and potential reserves are concentrated in New Mexico, Wyoming, and the Colorado Plateau, the incremental mining and milling activity would be expected to occur there.

1/ The subject area is estimated to provide 500 thousands bbls. of crude oil and 2.5 billion cu. ft. of natural gas per day by 1975.

The number ofplants in the planning or construction stage indicates that incentives to develop nuclear power facilities are already strong. The inability of utilities to assure long-term supplies of oil and gas has been the greatest stimulus to construction of nuclear plants. However, delays in equipment deliveries, public opposition, environmental objections, and legal difficulties have set back nuclear development.

Time Lag

Since planning, licensing, and construction lead times are at least six to eight years, no new additional nuclear plants could be expected to be a substitute source of energy before 1980.

Future costs of electricity produced by nuclear power are difficult to predict. Factors that tend to lower costs include technological improvements, lower fuel expenditure over the life of the plant, larger plants with economies of scale in capital and operating cost, standard components, and improved construction methods. However, because of the lead times involved nuclear power plants built as alternatives to the proposed program would have to be planned and built with today's technology.

Factors that tend to increase costs include longer lead time, poor labor productivity, added safety features, higher installed prices for plant equipment, and possibly higher costs of capital. Nuclear plants are expected to be competitive with fossil fuel plants in most areas of the United States.

c. Technological Feasibility of Substitution

Given the present energy-using technology, nuclear power can essentially only substitute for oil and gas used by electrical utilities and on site heating facilities. Even here it is not a complete substitute. Nuclear power plants are designed primarily for base load operations; they cannot be expected to displace peaking or cycling units. Electricity produced from nuclear power also could substitute for household heating by heating oils and natural gas.

d. Environmental Impact of Nuclear Power Generation

Environmental problems which could occur in nuclear power generation are associated with surface and subsurface mining of uranium ore, changes in land use, disposal of waste heat generated by less efficient nuclear plants, a small risk of serious accidents, and the safe storage of highly radioactive waste materials.

In 1970, 53% of production came from underground mines with most of the remainder coming from open-pit mines.

Uranium mining is largely concentrated in relatively isolated semi-desert areas distant from large population centers. The removal of vegetable cover and the creation of overburden and waste rock result from uranium mining. Open-pit mines require considerable acreage, reducing the suitability of the area for other uses such as grazing, wildlife and some types of outdoor recreation.

In underground mining, the extraction of ores requires some accumulation of waste rock in dump areas. Planning for sequential land use, followed by reclamation of mined land and the backfilling of mined-out stopes and pits with waste rock, can substantially reduce land use problems.

In underground mining in the 1950's excessive exposure to radioactive radon daughter products resulted in a high incidence of lung cancer. However, maintenance of vastly reduced annual exposure limits is expected to decrease incidence of lung cancer to a level just slightly above that of the population as a whole.

Because of low concentration of U_3O_8 in uranium ore, milling the ore produces considerable amounts of low level radioactive tailings that must be retained in well constructed tailings dams to prevent erosion and leaching. Tailings are unsuitable for use as fill material where human exposure might result. To minimize erosion from above ground storage, the tailings should be covered with gravel or dirt upon which a vegetative cover can be established.

Above ground storage of tailings requires considerable land area and displaces other uses. In the future, an increasing amount of tailings may be utilized to backfill mined-out stopes and open pits.

Mill tailings are a hostile environment for nearly all biota. The specific adverse effects on overall health of biota are not fully known; current evidence indicates increasing concentrations through upward stages of food chains.

Assuming an average of three 1,000 MW units per site, the construction of 36,000 MW of additional nuclear capacity by 1985 could require 12 additional plant sites (less if some units were added to existing plants). Under current siting criteria, these would be located at some distance from population centers. Assuming 500 acres per site (based upon an exclusion area of one-half mile radius around each plant), these plants would require a total up to 6,000 acres from which other uses would be excluded.

Depending on the capacity of the transmission lines which would be required if nuclear energy were to be a substitute energy alternative, the transmission line rights-of-way would require the use of ten to fifteen acres per mile of line. Certain types of development such as residences, would be excluded although such land would still be largely available for other purposes, such as recreation. These additional transmission lines would have an adverse aesthetic impact by disrupting some scenic vistas.

Construction of the plants would present some short-run environmental problems, such as the erosion of excavated materials. Special measures to prevent erosion of excavated materials with subsequent siltation will be taken.

Operation of the nuclear plants will generate considerable amounts of waste heat given their comparatively lower thermal efficiency

(around 33% compared to 40% for new fossil-fueled thermal efficiency plants). Given this difference in efficiency and on the assumption that fossil fuel plants release around 15% 1/ of their waste heat directly into the atmosphere, a light water reactor would release approximately 50% 2/ more waste heat into its cooling water than a fossil fuel plant of similar size. The effects of this waste heat will depend upon the cooling method used and the location of the plant.

The use of wet cooling towers, removing the heat by evaporation into the atmosphere, would not pose the problems of adverse thermal effects. However, water vapor from the cooling operations could have substantial effects on local haze, fog, cloud, and ice formation. Chemicals released in the cooled water or evaporated plume could also have effects on downstream and downwind biota.

The use of cooling ponds would produce less evaporation than wet cooling towers, but haze, fog, cloud, and ice formation would still occur during periods of sub-freezing temperatures. The ponds require additional acreage (an estimated 1,000-2,000 acres per 1,000 MW unit). These may have recreational uses, but they would also displace previous land uses.

1/ Energy Research Needs, Oct. 1971, Section IX, Resources for the Future, p. 19.

2/ Ibid, Section VI, p. 15.

Assuming a 15-20 degree F temperature rise, a "once through" method of direct discharge into the original source for a 1,000 MW plant would require 270-360 billion gallons of water per year. The effects of using a "once through" method of cooling heated water depend in part on the size of the body of water into which this heated water is discharged. The effects along ocean sites, the Great Lakes, and very large rivers are likely to be modest as the heat is more readily dispersed and more easily avoidable by aquatic species. Along smaller lakes and rivers or in bays with limited circulation, the effects can be more significant. Within the affected areas, higher water temperature can produce fish kills, interfere with fish reproduction, disrupt food chains, decrease dissolved oxygen content, drive out desirable aquatic species and encourage the growth of undesirable algae which may speed up eutrophication. However, sometimes the heat can be used for aquaculture and other beneficial uses.

Nuclear power plants, unlike fossil fuel plants, do not emit the usual products of combustion such as particulates, sulphur oxides, and nitrogen oxides. Hence, they do not generate the air pollution problems stemming from or require control measures for, such emissions. However, they do produce radioactive emissions whose release must be strictly limited if adverse affects to the health of humans and other biota are to be avoided.

In the normal operation of the incremental nuclear generating units, there would be very small amounts of radionuclides discharged in the cooling water and gaseous plant effluents. But, assuming that present standards will be maintained and enforced (these limit the release of radioactivity to no more than would expose an individual at the plant boundary to 1% of the individual maximums allowed), the effects of the amounts released are likely to be negligible, as the average additional annual dose which the affected population would receive, would be three to four orders of magnitude less than the average level of natural radiation exposure.

The operation of nuclear plants poses some risk of accidents. Nuclear plants are designed to minimize accidents or their adverse effects if one does occur, utilizing a "defense-in-depth" principle. This includes designing and constructing plants in such a way that accidents are prevented, designing and constructing plants to contain the effects of accidents which do occur, and siting reactors away from areas of high population density. Plants are designed to withstand a design basis accident (DBA), defined as the worst malfunction considered to have a probability of occurrence high enough to warrant corrective action. For light water reactors, the worst DBA considered is usually a major rupture in the cooling system. The maximum radiation dose which could be received at the site boundary if such an accident occurred is estimated for some plants to not exceed the annual dose obtained from natural radioactivity.

The nuclear fuel cycle requires the transportation of radioactive materials by truck or rail at several stages. The transportation of spent fuel elements from reactors to processing plants and of high-level waste from reprocessing plants to storage sites poses a potential hazard of considerable magnitude. Existing transportation regulations and cask designs have been developed to insure that even if accidents in transporting these materials do occur, no radioactivity will be released to the environment. For the transport of the spent fuels and high-level wastes associated with an incremental 36[illegible],000 MW capacity, a very small number of accidents could be expected to occur during a 25-year operating life. However, these are not expected to produce any major adverse effects other than those which could be expected from any other transportation accident.

Spent fuel assemblies from reactors are first partially cooled at the plant site and then transported to fuel reprocessing plants where usable nuclear fuel materials are recovered from them and radioactive wastes are separated. Existing reprocessing capacity is sufficient to handle this relatively small incremental load as an alternative to the production from the proposed OCS sale.

While radioactive emissions during reprocessing are greater than those occurring during normal power generation, the estimated dose to the affected population is still two orders of magnitude below

natural levels. Hence, the impact of these emissions is not expected to be significant, even though the chronic effects of such low level radioactivity are not yet wholly known.

The high-level radioactive wastes remaining after reprocessing are first concentrated and stored in solution for five years, then evaporated to solids, sealed in containers, and put into long-term storage.

The 36,000 MW of incremental capacity would produce around 288,000 to 384,000 gallons of high-level waste per year, using a cumulative storage capacity of 1,440,000 to 1,920,000 gallons. This liquid waste, when evaporated, would yield around 2,880 to 3,840 cubic feet/year in solid waste materials for each year of operation.

Because of their high concentrations of radioactive nuclides and very slow rates of decay, these waste materials must be isolated from the biosphere for hundreds of thousands of years if adverse effects to living organisms are to be totally avoided. The concept of storage in salt beds has been termed satisfactory by a National Academy of Science Advisory Committee. Pilot studies have been conducted for several years and are continuing to determine the acceptability of the specific sites. In the meantime, waste will continue to be stored in below surface man-made engineered storage facilities.

5. Increased Use of Coal

Since coal is the most abundant fossil fuel in the Nation, full consideration must be given to its use in solid form. A later section discusses the feasibility of coal based synthetic liquids and gases.

The major problems of increased use of coal as a solid fuel are those associated with the meeting of air quality restrictions. These are particularly significant relative to power generation uses since the largest market for coal is in the eastern portion of the Nation and the major deposits of low sulphur coal are in the western states. Considerable research is being devoted to the development of economically feasible processes for the treatment of coal before burning to remove excess sulphur, to improve combustion processes, and to remove pollutants from stack gases after combustion. Where air quality standards can be met, coal can substitute for oil and gas at facilities designed to use solid fuels. To the extent of substitution feasibility, coal could be considered as a substitute for oil and gas.

The following sections describe the problems related to the mining and processing of coal.

a. Description of the Alternative

The United States is well endowed in coal resources

with its deposits underlying 458,600 square miles in 37 states. Coal resources, remaining to be produced, were estimated by the Department of the Interior in January, 1972 at 3,200 billion short tons of which 2,800 billion short tons are at depths less than 3,000 feet, and 1,600 billion short tons are less than 1,000 feet below the surface. About 390 billion short tons are commercially recoverable under present economic conditions and mining technology. 1/

The quality of coal has become increasingly important as restrictions are updated, and new regulations are imposed by local, State, and Federal governments on the utilization of fuel containing excessive quantities of sulphur, nitrogen, and particulate matter. As a result of these restrictions, low-sulphur coal, or coal containing less than one percent sulphur, is in great demand for power generation, steel, and manufacturing. Throughout the United States, fossil fuel consumers are being forced by public demand and law to use low-sulphur fuels.

At present, the greatest need is for low-sulphur bituminous coal with a low ash fusion temperature for use in the power plants of the eastern United States. There is an acute shortage of this

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1/ U.S. Congress, Senate Committee on Interior and Insular Affairs, The President's Energy Message, A National Fuels and Energy Policy Study Hearings, 1971, 92nd Congress, 1st Session, p. 90.

type of coal east of the Mississippi River; however, there is an abundant supply of low-sulphur bituminous and sub-bituminous coal and lignite in the Rocky Mountain States. The following discussion will be directed toward that area.

The remaining resources of low-sulphur bituminous and sub-bituminous coal and lignite in the Rocky Mountain States were estimated to be 874 billion short tons as of January 1, 1967. 1/ Of this amount, 188 billion short tons are in beds ten feet or more thick found less than 1,000 feet below the surface. Recoverable resources are estimated at 440 billion short tons to a depth of 3,000 feet and 94 billion short tons to a depth of 1,000 feet. Since 1967, coal production in the Rocky Mountain States has been about 100 million short tons. Therefore, it is assumed that 94 billion short tons are still available as of January 1972. 2/

Approximately 45 billion short tons of the recoverable resources could be extracted by open pit mining, 3/ and 25 billion short

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1/ Paul Averitt, "Coal Resources of the United States: January 1, 1967" U.S. Geological Survey, Bulletin 1275, p. 1, 1969.

2/ Averitt, 1972, oral communication.

3/ Ibid.

tons are sufficiently well known as to character, thickness, and tonnage as to be classified as reserves. 1/

It is estimated that the subject lands will produce 500,000 barrels of oil per day and 2.5 billion cubic feet of gas per day by 1975. The energy produced from these lands in 1975 would be equivalent, on an annual basis, to the energy produced by 100 million short tons of 11,000 btu/lb. coal. In the five-year period from 1980 to 1985, oil and gas production from the proposal would supply energy equivalent to 493 million short tons of coal.

The coal resources of the Rocky Mountain States, if interchangeable for other energy sources forms, could be more than adequate to provide the energy needed even if production from the subject lands is not obtained. However, most reserves of low sulphur coal are dound in the Western states, far removed from the areas deficient in a supply of energy. Other limiting factors are the degree of substitutability of coal for oil and gas and the impact of developing a coal industry capable of producing an additional 500 million short tons of coal during the five-year period from 1980-1985.

1/ USDI, Bureau of Mines, "Stripable Reserves of Bituminous Coal and Lignite in the United States", Information Circular No. 8531, p. 15.

At present, very large open pit coal mines may produce five million short tons of coal per year. Very large underground mines may produce 2 million short tons per year. In order for the Rocky Mountain coal industry to produce the additional tonnage needed each year from 1980-1985, approximately 50 large underground mines or 20 large open pit mines, or smaller mines, or some combination thereof, would be necessary. Such mines could become operational only after considerable study of reserves, water supplies, constructing of utility and transportation facilities, and market requirements. Finally, a labor force would have to be found and trained to produce the coal within the health and safety standards of the Federal, State and local governments.

About one-half of the remaining coal resources in the Rocky Mountain States are found in thick beds underlying the northern part of the Great Plains. The coal generally has a low ash fusion temperature, a low-sulphur content, a substantially reduced heating value, and high volatile matter content. These characteristics suggest that this coal would be preferred for power generation, gasification, and liquefaction.

The total remaining coal resources in the basins of the Rocky Mountain are very large, nearly as great as those in the Northern

Great Plains, but extremely thick beds are a rarity rather than a common occurrence.

At a few localities within the Rocky Mountain States, deposits of metallurgical grade bituminous coal and anthracite are known and some are actively mined. Generally, the coal from these deposits is not suited for power generation, gasification and liquefaction.

The coal resources of both the Northern Great Plains and the Rocky Mountain basins are so large that the locations of open pit and underground mines would likely be determined by nearness to adequate water supplies, transportation facilities, and the plans for mine-mouth power plants. Extensive governmental ownership of the resources indicates that mining, rehabilitation, and environmental controls and procedures imposed on mining operations could be fully effective, since they would be administered in large part by the Department of the Interior and cooperating State governments.

(i) Use of Coal as a Solid Fuel

The sulphur content of U.S. coals ranges from 0.5 to over 7 percent. Currently, most U.S. production comes from states east of the Mississippi where 43 percent of the reserves contain more than 3 percent sulphur and only 20 percent of the reserves contain 1 percent or less.

Most of the low sulphur coals (1 percent or less sulphur) are found in the western states which contain some 65 percent of the U.S. reserves. At the present time, transportation costs and facility limitations prevent commercial movement of these reserves to eastern markets.

Recent environmental regulations applicable to new electric generating facilities restrict the emission of sulphur dioxide to 1.2 pounds per million btu of fuel as fired; for bituminous coal, this is equivalent to about 0.7 percent sulphur. It is necessary, therefore, to reduce the sulphur content of the coal prior to burning or to remove sulphur oxides from stack gases following combustion in order that coal may continue to be used for power generation.

Mechanical cleaning of raw coal is not a solution to the problem, since only a small fraction of American coals can be cleaned sufficiently to meet sulphur emission controls and standards. Mechanical cleaning affects only pyritic sulphur and leaves untouched the 40 to 60 percent of the sulphur that is bound in the organic structure of the coal. In addition, freeing the small particles in which pyrites occurs requires fine grinding prior to cleaning, which in turn adversely affects the cleaning efficiency and restricts the methods of cleaning that can be applied.

Coal, especially high-sulphur coal, is available in large quantities in close proximity to consuming markets. New coal burning plants could be built if air quality standards can be met but economics for coal desulphurization are marginal and optimistic assessments of economics are generally based on a substantial credit for sale of byproduct sulphur. Recently, the supply of sulphur has exceeded demand and the market cannot be expected to accommodate additional volumes from coal desulphurization.

(ii) Open Pit Mining

Near surface coal (0 to 200 feet) generally can be extracted by open pit or surface mining. This method involves the removal of the top soil and rock (overburden) to expose the coal bed, removal of the coal, and replacement of the spoil material and, in some instances, replacement of the top soil. Usually this is accomplished by working in large parallel trenches using the overburden of the second trench, or cut, to fill the first trench.

Surface or open-pit mining of coal has become a major source of solid fuels and, unless restrained by environmental restrictions, all evidence indicates that this method will increase in importance. For example, in 1929, open pit coal production amounted to three

percent of the total United States production. 1/ In 1969, however, open pit mining accounted for approximately 200 million short tons or 35.2 percent of the 560 million short tons total U.S. production. 2/ It is estimated that for the year 1971, the amount of surface mined coal will have increased to about 50 percent of total U.S. production.

The principal reasons for this growth are: (1) full production can be reached quickly, (2) the coal can be mined more cheaply, and (3) open pit mining is much safer than underground mining.

(iii) Underground Mining

Coal too deeply buried to be extracted by surface mining would be recovered by underground mining. Because most of the coal resources in the Rocky Mountain area are on public, Indian, or State lands, environmental impacts can be minimized by effective enforcement of Federal and State operating regulations.

Exploration activity in the Rocky Mountain States has not been directed towards obtaining the data necessary to design efficient methods of underground mining in thick coal beds. Generally,

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1/ F. E. Cash and Bernewitz, "Methods, Costs and Safety in Stripping and Mining Coal, Copper Ore, Iron Ore, Bauxite, and Pebble." "Phosphate", USDI, Bureau of Mines, Bulletin 298, 1929, p. 9.

2/ J. J. Gallagher and L. W. Westerstrom, "Coal-Bituminous and Lignite", Minerals Yearbook. Bureau of Mines, 1969, p. 309.

exploration activities by industry have been directed toward development of near surface reserves for open pit mining. Numerous questions concerning local geologic phenomena and mining conditions remain to be answered about the deeper resources before large-scale underground mines could be efficiently operated at most places. Principal among these are: roof strata thickness, composition, and strength; coal bed continuity, quality and thickness; bottom strata thickness and composition; and the presence or absence of fault systems, aquifers, or explosive gas-bearing strata. In addition to affecting mine safety and production efficiency, these geologic phenomena and mining conditions could strongly influence the environmental impact of large-scale underground mining.

Underground recovery of coal from beds less than ten feet thick averages about 57 percent 1/; however, as coal bed thickness increases above ten feet, the recovery percentage decreases drastically. This decrease is related to the equipment used underground, none of which has the capability of efficiently extracting coal from beds over ten feet in thickness. Equipment manufacturers have not been interested because of a lack in demand in designing machinery specifically for mining thick beds.

1/ R. L. Lowrie, "Recovery Percentage of Bituminous Coal Deposits in the United States", USDI, Bureau of Mines, 1968, p. 11.

b. Incremental Production

Adequate coal reserves exist in the United States to fulfill that energy demand to be supplied by the proposal.

c. Technological Feasibility of Substitution

Increasing coal production as an alternative to the proposal would present no new technological problems, however, if the 100 million short tons of annual coal production required should be furnished totally by surface mines, it is believed that 20 mines of five million short tons annual capacity each would be required. Currently, a mine of this magnitude employs 610 personnel with a capital expenditure of about $40,000,000. Therefore, in order for surface mines to supply the coal needed annually, 12,200 employees would be needed with a total capital expenditure of $800 million. 1/ This capital expenditure does not include the necessary financing for coal cleaning facilities.

If the Rocky Mountain States should have to produce an equivalent amount of energy from coal, the severe short-term environm ental impacts of surface mining could be minimized by underground mining. The manpower requirements and capital expenditures, however, would be large. On the basis of an annual production rate of about 2 million short tons per underground mine, approximately 50 underground mines would be needed. Manpower for these operations would total about 25 thousand employees and capital expenditures would approximate $1,200 million. 2/

1/ National Petroleum Council, Coal Task Group, "An Initial Appraisal, 1971-1985", U.S. Energy Outlook, Vol, II, 1971, p. 136.

2/ National Petroleum Council, Coal Task Group, "An Initial Appraisal, 1971-1985", U.S. Energy Outlook, Vol. II, p. 136.

d. Environmental Impact

Open Pit Mining

There generally are no favorable environmental effects to be found in the immediate area surrounding a surface coal mine. There are many serious environmental problems that are directly related to open pit mining. Principal among these are:

Open pit mining disturbs a considerable amount of surface acreage. As of 1967, it is reported that open pit coal mines were responsible for 41 percent of the land disturbed by surface mining in the United States. 1/ Predictions regarding the total size of the areas which would be disturbed by the surface mining of nearly 100,000,000 short tons of coal are shown in the following table:

PRODUCTION BY SURFACE MINING METHODS

(BASED ON 1,800 TONS PER ACRE FEET)

(FIGURES BASED ON 100,000,000 TONS PRODUCTION ANNUALLY OVER 5-YEAR PERIOD)

Coal Bed Thickness (Feet)	Recovery Factor (%)	Coal Avail. Per Sq. Mi. @ 80% Rec. (Tons)	Area Disturbed Annually (Sq. Mi.)	Area Disturbed (1980-1985) (Sq. Mi.)
10	80	9,216,000	10.8	54.0
15	80	13,824,000	7.2	36.0
20	80	18,432,000	5.4	22.0
25	80	23,040,000	4.3	21.5
30	80	27,648,000	3.6	18.0
35	80	32,256,000	3.1	15.5
40	80	36,064,000	2.7	13.5
45	80	41,472,000	2.4	12.0
50	80	46,080,000	2.1	10.5

1/ USDI, Surface Mining and Our Environment, A Special Report to the Nation, 1967, pp. 53-54.

Additional open pit mining sufficient to satisfy the 493 million short ton energy requirement between 1980 and 1985, could result in the disturbance, and the need for rehabilitation of as much as 34,560 acres of land.

Climatic conditions are extremely important in considering the rehabilitation of mined lands in the Rocky Mountain States. Obviously, without proper moisture, the reseeding of reclaimed lands would serve little purpose and erosion processes would soon destroy the contour of the rehabilitated lands. The following table shows the rehabilitation cost on a per ton basis for varying degrees of restoration.

ESTIMATED COSTS IN CENTS PER TON OF COAL FOR REGRADING, RESEEDING, AND REVEGETATING STRIP-MINED LANDS TO A PLEASING, NATURAL CONTOUR

Assumed tonnage of coal recovered per acre	Estimated costs of reclamation per acre(dollars)				
	$1,000	$2,000	$3,000	$4,000	$5,000
10,000	.10	.20	.30	.40	.50
20,000	.05	.10	.15	.20	.25
30,000	.033	.066	.10	.13	.17
40,000	.025	.05	.075	.10	.13
50,000	.02	.04	.06	.08	.10
100,000	.01	.02	.03	.04	.05

Disruption of the land surface by open pit mining, unless proper precautionary measures are implemented, has adverse impacts on the local environment, leisure time activities in the area, and nearby residential and industrial activities.

Most coal deposits contain contaminants and must be washed. It is assumed that under ideal conditions, a 5-percent washer loss would occur, creating the problem of disposal of approximately 25 million short tons of waste material (over 5 years). This problem may not be critical for surface mines where pits, from which the coal would be extracted, could receive this material. Ultimately, the mine pits would be backfilled, leveled, the top soil replaced, and the area reseeded.

Other problems related to surface coal mining are acid water developing in the open pits and in spoil piles, erosion of pits, and dust. Each of these problems can be handled effectively by requiring the mining companies to observe environmental regulations. However, if they are not handled properly, damage can occur to the local environment. Additionally, area downstream of the mine and processing plant could be adversely affected.

Surface mining operations also generate fairly significant volumes of noise and vibrations. Modifications of the habitat, alteration of ground cover, alteration of drainage systems, destruction of land forms, and siltation of nearby streams may also occur. With the implementation of proper rehabilitation and environmental safeguards, the unfavorable impacts described can be reduced to short-term problems. Proper supervision within the scope of present environmental

regulations would result in mined lands being returned to "as good or better than found conditions", in that some restored lands could lend themselves to recreational sites, lake impoundments for boating and fishing and picnic areas. The short-term economic and energy profits derived from surface mining can be realized without long-term degradation of the environment if there is complete cooperation between all companies, land owners, and governmental bodies acting in concert.

Once mined, the impact of coal production is still felt in the transportation to the market areas. One way to eliminate this impact is to situate new power plants at or near mine locations. The transport of electricity to the market areas by transmission lines causes fewer environmental problems than the transport of a vast quantity of coal.

If the transport of the coal itself is necessary, four systems would be available to the Rocky Mountain States. These systems are: trucks, railroads, conveyors, and coal slurry pipelines. A fifth system, water transportation, may be discounted because of the lack of navigable waterways. Each system has advantages that make it economically attractive. Selection of a system would be strongly influenced by the distance to a utilization plant. Relative costs of coal transportation systems are given in an attached table.

Truck transportation is commonly used for relatively short hauls, as in supplying mine-mouth utilization plants. The roads are usually less than 5 miles long, on land leased by the mining company, and have little effect on the general public. In the Rocky Mountain States there are usually no intersections with public roads and the traffic is generally related to the mining operations. Trucks can transport ash and spent plant materials back to mine pits for disposal, thereby using the haul in both directions as well as solving a refuse disposal problem.

Transportation Cost in Mills Per Ton Mile

	Maddex 1/	Aude 2/	Wellman 3/
Ocean shipping	0.3-10		
Pipeline	1.5-10	3-7 (More than 50 miles no slurry preparation)	
River barge	2-4		
Railroad	4-15	4-9 (Unit train more than 400 miles)	
Truck	55-70	50-80 (One way haul with empty return)	
Conveyor belt		20-60 (Less than 15 Miles)	
Pneumatic			130 (600 tons per hour, 5 miles)

1/ Philip J. Maddex, and Ole Skaarup, "The Cost of Transporting Ores and Raw Materials in World Markets." Mining Engineering, June, 1970, pp. 56-57.

2/ T. C. Aude, N. T. Couper, T. L. Thompson, and E. J. Wasp, "Slurry Piping Systems: Trends", Chemical Engineering, June 28, 1971, pp. 74-90.

3/ Paul Wellman and Sidney Katell. "Economic Evaluation of Pneumatic Transport of Coal at 200, 400 and 600 tons per Hour. Paper in Pneumatic Transportation of Solids, Proceedings: Institute of Gas Technology, Bureau of Mines Symposium, Morgantown, W. Va., October 19-20, 1965. Compiled by J. D. Spenser, T. J. Joyce and J. W. Faber, 1966, p. 184.

The impact of rail transportation varies to some degree with the types of motive power used. Diesel locomotives are sources of exhaust gas and noise pollution; electric locomotives are not sources of air pollution per se, however, the pollution source is the power station. Positive factors include the transporting of commodities to fulfill the needs of inhabitants in the area and haulage of ash and spent materials back to the mine pits for disposal.

Rail installations can be constructed to lessen the impact on the environment. Ribbon rail with thermite welded joints can be installed to reduce tract noise. Rights-of-way can be fenced, for safety to animals and humans, with underpasses and grade separations provided for heavily traveled roads. Coal hoppers can be partially covered, or the coal can be sprayed to reduce dust loss in transit. Coal loading and unloading facilities can be designed to consider aesthetics. Cut and fill areas can be constructed with gentle slopes to permit the growth of vegetation and borrow areas can be covered with top soil and then revegetated.

Overland conveyor systems are used to transport coal from mine to preparation plant, from truck or railroad unloading hoppers to storage areas or bunkers and directly to some utilization plants.

Generally, these installations are short; however, they may be as long as 15 miles. Although conveyor structures and transfer point housings are obvious intrusions on open space vistas, this impact can be lessened through selective use of colors. Rights-of-way for conveyor installations require less land than either truck or rail rights-of-way and do not require the extensive cuts and fills needed by other transport systems.

The least obtrusive type of transportation system from both land use and visual standpoints, are coal slurry pipelines. Land surface requirements are minimal because the pipeline is buried and appears at the surface only at drainage crossings and pumping stations. Slurry preparation plants, pumping stations, and terminal coal dewatering and storage facilities are the only permanent structures. The pipeline, after burial, does not interfere with the free movement of vehicles, people or animals. The only noise sources are at the slurry preparation plant and at pumping stations. Dust problems associated with pipelines are confined to the slurry preparation plant where the coal is crushed, screened and stored and commonly employed suppression methods minimize this problem.

The major adverse environmental impacts of the transportation systems are air and noise pollution, safety, the amount of land required for rights-of-way, trash disposal and aesthetics.

Air pollution sources are exhaust emissions, road dust, and coal dust. The level of adverse exhaust emissions can be reduced through efficient engine maintenance; road dust can be reduced by haul-road surface treatment such as hard surfacing, oiling, or applying water-chemical solutions; and coal dust can be reduced by truck covers and spraying. Although mufflers can reduce the level of noise pollution, truck haulage, because of the large number of noise sources and frequent trips, is commonly recognized as the noisiest system of transportation.

Collisions between trucks, other vehicles, and animals can occur but do not normally constitute a serious public hazard because haulage roads generally are confined to the mining and processing areas.

Land use committed to truck haulage is the largest of any of the coal transportation systems.

In the Rocky Mountain States, the presence and movement of large numbers of trucks in open areas may be aesthetically objectionable to the public, especially if the haulage roads are near public use areas.

Rail transportation systems using diesel locomotives are sources of air and noise pollutants from engine exhaust systems. Effec-

tive maintenance of engine combustion systems and efficient mufflers can reduce the air and noise pollution levels from these systems. Coal dust lost in transit can be reduced by using partially covered hoppers or by oiling the coal during loading. Dusting during loading and unloading can be reduced with a combination of dust suppression sprays and enclosed chutes or bins.

The right-of-way for a railroad constitutes a permanent commitment of the land surface to this use making it unavailable for other uses. Free travel of vehicles, people and animals across the committed area is restricted. The potential for collisions with trains exists.

In the open or scenic areas of the Rocky Mountain States, railroad rights-of-way may be considered as aesthetic intrusions, especially if large trestles, overpasses, or cut and fill areas are required. Cut and fill areas can be reclaimed as mentioned in conjunction with truck transportation systems. The visual impact of trestles, overpasses, and other appurtenant structures can be minimized with effective combinations of eye-pleasing designs and unobtrusive colors.

Conveyor system installations likewise constitute a permanent commitment of the land surface and restrict free movement of

vehicles, people, and animals. The right-of-way width is less than that required for truck or railroad transportation systems. Uncovered or partly covered conveyors allow loss of dust in transit because of exposure to winds and falling material may constitute a safety hazard to persons or animals. Conveyor systems, fenced or completely enclosed, can reduce or eliminate these hazards. Conveyor support structures, either frame or suspension type, as well as the conveyors, are obvious visual intrusions. Color treatment of support structures, enclosures, and transfer structures can lessen this impact.

The principal impacts of coal slurry pipeline systems are: the permanent commitment of land; providing an adequate water supply; and water disposal. Large quantities of water, at the rate of one tone of water per ton of coal, are required to transport coal in the Black Mesa, Arizona, Pipeline 1/ (Arnold, 1969, p. 8). In water deficient areas, this method may not be an efficient transportation alternative.

1/ J. M. Arnold, "Discovery and Development of Peabody Coal Company's Black Mesa Mine", Society of Mining Engineers and American Institute of Mining and Metallurgical Engineers, Preprint No. 69-F-349, 1969, p. 8.

Water disposal problems at the terminus of a pipeline could have an impact on water quality if not properly contained or when not economically feasible to recycle the water for transportation purposes. Coal slurry destined for power, could be dewatered, the "spent" water used for cooling tower makeup, ash handling, and/or evaporated in disposal ponds. The Mohave generating station in Nevada is utilizing water from the Black Mesa Pipeline in this manner.

The disposal of solids and water removed from sections of a plugged pipeline could cause environmental impacts. Holding ponds, equal in capacity to the upstream pipeline, could be provided at pumping stations and at the coal slurry preparation plant for disposal of removed plugs. The water could be evaporated and the coal could be left in the impoundment unless provisions are made for recovery. Compaction and sealing would prevent spontaneous ignition, erosion, and accompanying siltation of the coal left in impoundments. The surface of the impoundment can then be revegetated to prevent erosion.

Large volumes of waste are generated during coal mining and processing. The volume of mine waste depends on the type and characteristics of top and bottom strata, the continuity of a coal bed, the tonnage mined, the amount of waste material included,

the specifications for which the coal is being prepared, and the efficiency of the processing equipment. Uncontrolled disposal of waste, especially that containing carbon and sulphur, constitutes a source of pollution. Water flowing over waste disposal areas may transport leached minerals to adjacent areas. Dust-size particles commonly are transported by winds to contaminate adjacent land. Noxious gases from burning waste may be hazardous to plants, animals and people. 1/

Waste disposal areas require a commitment of land resources and, if poorly constructed, present an unattractive appearance to viewers. Slides and slump failures, where waste is deposited on slopes, may not only adversely effect land and water resources but also create a safety hazard.

Construction of slurry impoundments on underlying pervious bedrock may result in pollution of the ground water. Percolation through the base of dikes permits slurry water to reach downstream drainage systems. Unless measures are taken by coal

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1/ L. M. McNay, "Coal Refuse Fires, An Environmental Hazard", USDI, Bureau of Mines, 1970, p. 8.

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operators to seal this type of disposal areas, unfavorable impacts can continue for decades. However, use of appropriate treatment methods on the part of coal operators, coupled with effective enforcement of waste disposal regulations promulgated by State and Federal Governments, can minimize such effects on the environment.

There can also be beneficial uses of waste materials. The rock removed during mining may be used as landfill providing an effective method of disposal.

Underground Mining

Subsidence of the ground surface is common above any abandoned and some active coal mines. The amount of subsidence relates to the mining method employed, the amount of coal removed, the thickness of the coal bed, and the composition and strength of rocks overlying the coal. Subsidence of large areas commonly destroys man-made structures and disrupts the ground water hydrology, cuts off surface and subsurface water recharge, adversely affects the quality of underground and surface waters, redirects the planned drainage of a mine, disrupts surface drainage, and in periods of heavy rainfall localizes flooding. It also, in some localities, causes land slides.

The most successful method of preventing or alleviating surface subsidence problems is to plan mining so that more pillars are left untouched. Unfortunately, this procedure results in less coal recovery. Pillars can be constructed of timbers and rock to make possible the mining of more coal than by simply leaving coal pillars in place to support the roof. Much additional research is needed to develop methods of underground mining which will minimize subsidence of the surface. If such methods cannot be implemented, the best solution may be to achieve as complete recovery of coal as possible during mining, then allow controlled subsidence to the point of natural stabilization and, finally, develop the land surface.

Ground and surface waters entering active underground mine workings are normally pumped to the surface for disposal. Because of the low-sulphur content of most Rocky Mountain coals, it is uncertain whether acid-mine water would be a problem in areas of large-scale mining and above average precipitation. If acid-mine water problems should develop, it is likely that the modern treatment methods employed in the coal fields of the eastern United States could be implemented to abate their impacts. The large volumes of sludge resulting from such treatment could be emplaced either in abandoned mine workings or in protected disposal

areas. Drainage of acid-mine water may be prevented by locating mine entries at elevations above the prevailing drainage level, by sealing abandoned mine entries, and by emplacing dams at critical points in abandoned underground entries and haulageways.

Unless controlled, mining and processing wastes contribute large volumes of sediment to nearby streams, are sources of acid drainage and, where waste piles are burning, are sources of air pollution. The most commonly used technique of preventing wide-spread scattering of mining and processing wastes is to compact the waste layers, followed by sealing with incombustible soil, after which vegetation is established to prevent infiltration of surface water and to minimize erosion.

An alternative to surface disposal of mine and coal processing waste is to return wastes to abandoned underground mine workings. This is currently being done to control surface subsidence in mined areas in compliance with restoration provisions of the Appalachian Regional Development Act of 1965, as amended. 1/ Methods of returning the waste to mined out areas concurrent

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1/ C. B. Kenahan and E. P. Flint, "Research and Programs on Recycling and Disposal of Minerals, Methal and Energy-Based Solid Wastes", USDI, Bureau of Mines, 1971, p. 24.

with active mining would appear to warrant attention of mining method researchers.

Dust from mine access roads, coal handling, and processing can be alleviated by hard surfacing roads, or through abatement techniques such as oiling or chemical treatment of the road surface. Dust from coal handling and processing can be abated by spray treatment at transfer points and by enclosing coal handling and processing structures. Dusting problems in live coal storage piles can be reduced by water sprays or oiling; dead storage piles can be sealed with asphaltic or chemical materials.

The potential for long-term environmental impacts from an underground mine can be diminished by identifying and eliminating pollution sources prior to closure of the mine. Most pollution sources can be eliminated by sealing and revegetating waste disposal areas; sealing and removing abandoned mine buildings and structures; and scoring, fertilizing, and revegetating disturbed surface areas. Consideration should also be given to flushing all wastes and utilization plant refuse into underground mine voids to remove sources of surface pollutants and to reduce possible surface subsidence.

A discussion of the favorable environmental effects of underground mining follows:

When subsidence of the land surface is prevented, the surface effects of underground mining generally are confined to the areas occupied by mine buildings, dumps, waste disposal banks and impoundments, water supply impoundments, or wells, coal transporttation systems, power supply structures, and mine supply storage yards.

The areal extent of environmental impacts associated with underground mining is dependent on the mining system being designated to assure a high level of environmental quality. Means of obtaining this assurance are State and Eederal regulations, and the development of an environmental ethic by all mine operators. The Mined Area Protection Act of 1971 (S. 993 and H. R. 5689), currently being considered by the 92nd Congress, is an example of pending legislation that would require all underground and surface operators to adhere to standards designed to protect the environment.

Several provisions of the mandatory safety standards issued under the Federal Coal Mine Health and Safety Act of 1969 have related environmental objectives, especially those standards for disposal of mine refuse and dust, for coal handling, and for transportation facilities.

Most older coal leases on Federal lands include a provision in the lease agreement for the protection of the land surface, natural resources, and improvements. This provision has been broadened over the years to include environmental considerations.

Underground mining is subject to minimal noises and vibrations and the surface environmental effects are of limited significance. Modifications of the habitat, alteration of ground cover, alteration of surface drainage systems and the necessity of fertilization application are also minor. The following environmental effects of underground mining, however, pose problems: alteration of ground water hydrology, the necessity of well drilling and fluid removal, the techniques of product processing and resultant waste, liquid effluent discharges and most accidents.

Many unfavorable environmental impacts of underground coal mining can be controlled largely through techniques developed and used in recent years. Prevention of environmental degradation by underground mining is dependent upon attitudes of mine operators and efficient enforcement of local, State or Federal regulations.

e. Health and Safety

Social costs in terms of health and safety of mine employees must be considered along with the capital expenditures and environmental costs of mining.

In 1970, there were 31 fatal and 1,010 non-fatal accidents connected with open pit mining. Underground mining was responsible for 219 fatal and 8,710 non-fatal accidents in 1970.

Black lung disease has been a serious problem in the past. Recent regulations and technological advances concerning the control of the quantity of dust in mining operations, however hopefully will go a long way to reduce or eliminate this coal mining associated health hazard.

6. Increase Hydroelectric Power

a. Description of the Alternative

The generating potential of any hydroelectric site is a function of both stream discharge and the height of fall; hence the better hydroelectric sites are concentrated in areas with heavy precipitation and large topographic relief. The following table shows the extent of U. S. potential and development of conventional water-power capacity:*

Geographic Region	Potential Power (10^3 MW)**	Percent of Total	Developed Capacity (10^3 MW)	Percent Developed
New England	4.8	2.7	1.5	31.3
Middle Atlantic	8.7	4.8	4.2	48.3
East North Central	2.5	1.4	0.9	36.0
West North Central	7.1	3.9	2.7	38.0
South Atlantic	14.8	8.2	5.3	35.8
East South Central	9.0	5.0	5.2	57.8
West South Central	5.2	2.9	1.9	36.5
Sub-total	52.1	28.9	21.7	42.0
Mountain	32.9	18.3	6.2	18.8
Pacific	62.2	34.6	23.9	38.4
Alaska	32.6	18.1	.1	0.3
Hawaii	0.1	0.1	-	-
TOTAL	179.9	100.0	51.9	28.8

Of the potential hydroelectric capacity of 179,900 MW in the U. S., 95,400 MW is yet to be developed in the lower 48 States. Of this 30, 400 MW is the potential for additional hydropower east of the

* Statistics as of January 1971 obtained from FPC.
** MW = Megawatts

Mountain States. Hydropower from Alaska, the Pacific or Mountain areas of the U. S. probably cannot be considered as sources of additional hydropower for the Eastern U. S. largely because the distance from consuming region and the related transmission problems would make the construction of transmission lines economically infeasible.

b. Incremental Production

The Federal Power Commission projects conventional electric generating capacity in the contiguous U. S. as follows:

Year	Total Generating Capacity (MW)	Total Conventional Hydro Capacity (MW)	Conventional Hydro as Percent of Total
1970	340,000	51,600	15.2
1980	665,000	68,000	10.2
1990	1,260,000	82,000	6.2

The geographic distribution of the projected 16,400 MW increase in conventional hydro capacity in 1980 over the 1970 capacity for the contiguous U. S. is as follows: 1/

Geographic Region	Incremental Hydro Capacity (MW)
Northeast	1,200
East Central	1,000
Southeast	1,700
West Central	- 500
South Central	700
Sub total	4,100
West	12,300
TOTAL U. S.	16,400

1/ Federal Power Commission, The 1970 National Power Survey, Part 1, p. 1-18-29.

Of the total incremental conventional hydroelectric capacity of 16,400 MW, 4,100 MW can be expected to come from areas other than the West, leaving some 30,000 MW to be developed in those areas.

The table below compares oil and gas production in 1980 anticipated from the proposal with eastern conventional hydropower potentials which may remain in 1980.

	Quantity	Btu's/Day
Expected Oil Production	450,000 B/D	2610×10^9
Expected Gas Production	2.5 billion cu. ft./D	2580×10^9
Remaining Hydro Power Potential	30,000 MW	1288×10^9

These figures demonstrate that oil and gas production anticipated from the proposal exceeds the potential hydropower.

c. Technological Feasibility of Substitution

Full direct substitution of hydroelectric power for oil and gas to be produced from the proposal would not be possible since at least 50% of the oil is for transportation, a use which cannot be supplied by hydropower. However, refinery yields of products, overall, could readily be modified to accommodate this substitution.

Even if all of the remaining potential hydropower were developed, and it were fully substitutable for oil and gas uses, it could serve only as a partial alternative to the oil and gas expected to be produced.

There also are factors of reliability of hydropower as a source of energy to meet base or peak requirements because of the seasonality of the energy form, and the fact that few dams are built solely for hydroelectric power generation. Irrigation, navigation, municipal, and industrial uses, and flood control are important, and frequently are the dominant uses which may not be fully compatible with power production needs.

d. Environmental Impact

A number of environmental impact statements filed by the Bureau of Reclamation of the Department of the Interior and by the Corps of Engineers describe environmental impacts of specific hydroelectric projects.

<u>Favorable</u>

Hydroelectric power produces no air pollution, radioactivity, waste heat, nor water pollution (with the exception of the loss of oxygen content in storage facilities). Dams valuable for hydroelectric purposes may be otherwise useful forsuch needs as irrigation and flood control. Lakes behind dams created for hydroelectric purposes provide recreational opportunities such as swimming, fishing and boating.

<u>Unfavorable</u>

Construction of a hydroelectric dam represents an irretrievable commitment of the land resources beneath the dam and lake, precluding other uses (agriculture, minerals, wildlife habitat, free-flowing river

recreation, and so forth). Alteration of river flows may lead to silting behind the dam, thus progressively reducing reservoir capacity and its effective use and finally, after many years, filling the lake. Alteration of downstream flows from power-plant discharges can cause scouring of banks and bottoms.

Fish and wildlife habitat may be significantly changed. The reproductive habitats of anadromous fish may be severely altered by dam construction, unless elaborate provision is made for fish ladders or other means to provide safe fish passage.

7. Modification of FPC Natural Gas Pricing

Analysis of this alternative has been commented upon formally by the staff of the Federal Power Commission (FPC). Their comments have been incorporated herein. The FPC staff has also provided informal assistance and consultation.

a. Description of the Alternative

Natural gas in interstate commerce in the United States is under FPC jurisdiction. Under this alternative FPC would permit interstate gas prices to rise to the extent needed to attract additional investment in domestic oil and gas exploration and development, onshore and offshore, to provide sufficient additional supplies of natural gas.

In 1954, the Supreme Court ruled that independent producers of natural gas, whose sale of gas goes into interstate commerce, were not exempted from regulation under the Natural Gas Act. Since then, terms of interstate gas sales, including pricing, have been subject to Federal regulation.

In 1960 the FPC departed from an individual company "cost-of-service" method price determination in favor of an "area rate" concept. The area rate method which has been upheld by the Supreme Court, involves the accumulation of data sufficient to determine the average unit costs associated with all aspects of natural gas production on an areal basis, instead of examining the costs of each producing company.

Recently, the FPC has modified its pricing policies to be more responsive to the current gas supply situation. Some FPC area price ceilings were raised about 35% during 1968-70, and still more recently the Commission has initiated major actions to stimulate natural gas exploration and development.

On July 16, 1971, FPC Opinion No. 598 set new, higher ceiling rates for the South Louisiana area and provided for a system of incentives to promote dedication of gas reserves to the interstate market. In support of its price action, the Commission observed that demand for gas as a "pollution-free fuel" is increasing and the price of alternative fuels is going up. It further concluded that there is, "a worsening gap between supply and demand, and that price must have a major responsibility for eliciting new supplies."

Similar higher ceiling prices were later granted in other major gas producing areas.

In furtherance of the concept of providing incentives, the Federal Power Commission in Order No. 455 dated August 3, 1972, offered an optional procedure for certificating new producer sales of natural gas. Under this option, sales of new gas at prices above existing ceilings, agreed upon by buyer and seller, may be certificated subject to certain constraints and possible future actions by the Commission. This alternate procedure is designed to assure interstate gas consumers, and the nation as a whole, an adequate and reliable supply

of natural gas at the lowest reasonable cost. It is not intended to replace geographical area pricing, but rather to provide an alternative procedure for certification of natural gas sales for new gas sales at rates above established area ceilings.

Since the FPC has modified its pricing to be more responsive to the supply situation, short of deregulation, it appears that this alternative has been implemented. In addition, since the FPC had full knowledge of and supported Interior's intentions regarding the proposed OCS lease sale, it is reasonable to assume that FPC price actions taken to date were not intended as an alternative to the proposed sale.

b. Incremental Production

In order to replace the amount of oil and gas expected to be produced from the proposal, the equivalent of an additional 5.3 billion cubic feet of gas per day would have to be stimulated through higher prices.

While there are logical and empirical reasons to expect that increased prices would provide incentives to accelerate the exploration and development of additional gas resources, uncertainties regarding investment responses and discovery rates preclude meaningful projections of price/production relationships.

c. Technological Feasibility of Substitution

Of the additional 5.3 billion cubic feet of gas equivalent per day that would have to be produced as a result of the implementation of this alternative, 2.8 billion cubic feet a day would have to substitute for the oil that is expected to be produced. As some incremental oil production may result as a by-product of increased gas exploration, the actual required substitution of gas for oil could be somewhat less than 2.8 billion cubic feet for a day.

d. Environmental Impact

Specific environmental impacts are not listed in this section because the environmental impact of increased production from onshore and offshore areas discussed elsewhere, are applicable to this proposed action.

Favorable

Since natural gas is the least polluting of the fissil fuels at the point of combustion, this alternative would benefit the environment to the extent that gas would be substituted for oil.

Unfavorable

Increased gas prices would raise the cost of gas to the consumer. Higher gas prices might cause consumers to prefer other energy forms which cause more pollution in their production, processing, distribution and use.

e. Health and Safety

The health and safety aspects of increasing onshore production as a result of modification of FPC pricing is essentially the same as the health and safety aspects of OCS production discussed inthis statement.

8. Modification of Market Demand Prorationing Systems

Consultation

This section has been forwarded to the Louisiana Department of Conservation and the State of Texas for their review and comments. Both these groups have appeared at a public hearing 1/ offering testimony on the feasibility of modification of market-demand prorationing systems as an energy alternative to additional development.

At the hearing, Ray T. Sutton, the Commissioner of Conservation of the State of Louisiance, testified that "the onshore and zone 1 production has peaked and is in a period of steady decline . . . For all practical purposes, Louisiana is now producing all the oil that can be produced efficiently. We have no reserve producing capacity". Furthermore, the commissioner added, unsatisfied market demand (as measured by nominations), exceeded 100,000 barrels per day in August 1972.

A similar testimony was submitted by the chairman of the Railroad Commission of Texas, Byron Tunnell, who stated, "Texas has no sifnificant reserve-producing capacity remaining". He noted that an increase of Texas allowable percentages by 32.5% achieved only a 12% increase in oil production. Mr. Tunnell concluded, "We have reached the peak of production at which Texas oil fields can be operated without harm to the reservoirs. Do not count on Texas for more oil and gas than is now being produced. It simply isn't there."

1/ Public Hearing of August 22 and 23 on proposed Louisiana OCS Oil and Gas General Lease Sale and Draft Environmental Statement, New Orleans.

Discussion

The objective of this alternative would be to obtain increased production from developed reserves that are being produced at less than maximum efficient rates (MER). The alternative would require those states prorationing oil production to market demand, to revise their laws and regulations so as to permit full production. This cannot be considered as an alternative to projected supplies from the proposal because declining U. S. crude oil productive capacity and increasing demand for crude oil will require production at maximum efficient rates.

Elimination of state market-demand prorationing would result in very little additional crude oil and natural gas production. Important exceptions to MER production currently remain only in the Elk Hills Naval Petroleum Reserve (which is not subject tc state market-demand prorationing and which will be discussed in a later section of the statement) and a small number of fields in Texas and Louisiana. Louisiana officials are reviewing producing potentials on a field-by- field basis, and indicate that the state will be producing at MER by early fall 1972.

Only three Texas fields, East Texas, Kelly-Snyder and Tom O'Connor were restricted below 100 percent of their respective market-demand factors as of September 1972. Conservation problems encountered at higher operating rates have compelled reduced production in these fields while unresolved issues of correlative rights to the crude oil also preclude higher production from East Texas. A very few Texas fields have MER's

in excess of 100 percent of their market demand factors and of these the largest, Yates, also has unresolved problems of correlative rights. Projections of United States petroleum production and requirements indicate that remaining potentials and newly developed capacity will be put into production as consideration of conservation, environmental protection and equity permit and the issue of market-demand prorationing will remain moot.

9. Oil Shale Production

a. Description of the Alternative

Large areas of the United States are known to contain oil shale deposits but those in the States of Colorado, Utah and Wyoming are of greatest potential for commercial shale-oil production. It is estimated that some 73 percent of the oil shale lands containing nearly 80 percent of the shale oil are public lands. The highest grade deposits occur over an area of 17,000 square miles (11 million acres) and contain an estimated 600 billion barrels of oil. Recovery of even a small fraction of this resource would provide significant amounts of energy adequate to supplement the Nation's oil supply for many decades.

Three retorting processes have been developed to the point of technological practicability, but none have been demonstrated and tested at a commercial production scale. The mining of the shale presents no particularly difficult technological problems as it can be done by conventional room and pillar underground mining or by surface mining techniques. The major process barriers to development of this alternaitve therefore are the need for full-scale demonstration and testing to prove the technology and develop necessary cost and other data for determining economic feasibility.

On June 29, 1971, the Secretary of the Interior announced plans for a proposed prototype oil shale leasing program which is designed

to ". . . provide a new source of energy for this Nation by stimulating the timely development of commercial oil shale development by private enterprise, and to do so in a manner that will assure the minimum possible impact on the present environment while providing for the future restoration of the immediate and surrounding area." The proposed program would make available to private enterprise, for development under lease, a limited amount of public oil shale resources. Such leases would be by competitive bonus bidding and would include assumption of certain royalty obligations to the United States.

The proposed program is in concert with the President's Energy Message of June 4, 1971, in which he requested the Secretary of the Interior to initiate "A leasing program to develop our vast oil shale resources, provided that environmental questions can be resolved." The environmental question has come under intensive review over the past 3 years and, in September, 1972, the Secretary released a 1,300 page draft environmental statement. 1/ That statement details the proposed program and assesses the specific impacts expected from prototype development plus development on private lands that may be stimulated by the Department's action should the program be implemented.

1/ "Draft Environmental Impact Statement for the Proposed Prototype Oil Shale Leasing Program", released September 7, 1972 by the U. S. Department of the Interior.

b. Incremental Production

The proposed prototype program depends on industry as to the timing of commercial production. It is not possible therefore, to determine the exact amount of oil that is to be expected in the future. For planning purposes, however, it is necessary to determine the maximum rate of development that may be expected. This was done for the Department's study 1/ and the estimates are quoted as follows:

> Commercial shale-oil production, under the most optimistic estimate, could begin about 1975 at a rate of about 18 million barrels per year (50,000 barrels per day), on the basis of anticipated technologic progress. The first generation technology needed for this rate of production would be improved from 1976 to 1980. This development stage will be reflected by only small increases in annual production of about 18 million barrels per year as the new technology is applied. By 1980 a productive capacity of more than 100 million barrels per year (300,000 barrels per day) could be established. More importantly, the technology probably will have been advanced to the point where large incremental increases in production could be achieved. Also, the nucleus of people, supporting

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1/ "Draft Environmental Impact Statement for the Proposed Prototype Oil Shale Leasing Program", released September 7, 1972 by the U. S. Department of the Interior.

services, facilities, and experience needed for this expanded effort will have been established.

After 1980 the second generation extraction-retorting systems would be expected to permit annual additions to shale-oil productive capacity of about 37 to 73 million barrels per year (100,000 to 200,000 barrels per day). The rate at which oil shale may be developed provides the framework within which subsequent calculations of the capital investments that will probably be required. Seven installations with a cumulative capacity of 400,000 barrels per day are assumed to be constructed on both private and public lands in the period 1973 to 1981. In the period 1981 to 1985 capacity is assumed to grow to one million barrels per day.

The cumulative 6-plant capacity of 300,000 barrels per day by 1979 reflects the necessary construction and evaluation phase of this new technologic development. Second generation technology could be expected to be available by 1980, enabling the large increases in capacity from surface processing systems. In-situ retorting may also be advanced to the point where the first commercial operation could be initiated. By 1985 cumulate capacity is estimated at 1 million barrels per day from both private and public lands.

Production of about 900,000 barrels per day of shale oil would be needed by 1980 to replace the energy expected from the proposal. The preceeding section has indicated that the maximum expected rate of shale-oil production in that year is 300,000 barrels; thus oil from shale is not a complete alternative.

It may be possible to accelerate the rate of shale oil production through a Federal program or by incentives or subsidies for private development. Such efforts, however, would not be expected to significantly increase shale-oil production over that now expected due to the long lead time required for the physical development of this resource.

c. Technological Feasibility of Substitution

Substantial production probably could be achieved by the 1980-1985 period. Before then, oil shale might provide an alternative to the proposal to a limited extent. However, since development is now only in the pilot plant stage, oil shale probably will not be available in significant quantities before 1980 due to a combination of economic, technical and environmental reasons.

Two major options are being considered for oil shale developments: (1) mining followed by surface processing of the oil shale and shale-oil; and (2) in-situ (or in place) processing. Of the two options, only the mining-surface processing approach is believed to have been advanced to the point where it may be possible to scale-up to commercial production in this decade. In-situ processing is in the experimental phase; commercial application of this technique cannot be expected prior to 1980. The relative state of knowledge of the various operations required in oil shale processing is shown in Figure 8-1. 1/ It is apparent from Figure 8-1, however, that various technical approaches are available for each phase of the operations, and no single system is likely to dominate the initial development of oil shale.

Until recent years, virtually all efforts to develop oil shale technology were directed toward mining, crushing, and above ground retorting. Oil shale processing in this manner would require the handling of large amounts of materials. Figure 8-2 indicates the materials flow through such an operation, beginning with mining and ending with final fuel products and various by-products. In certain locations, the oil shale deposits contain minerals that may be amenable to recovery of additional by-products such as soda ash and alumina.

1/ Most of the refining operations shown in Figure 8-1 would be performed outside of the oil shale region, at refinery centers near markets for the products.

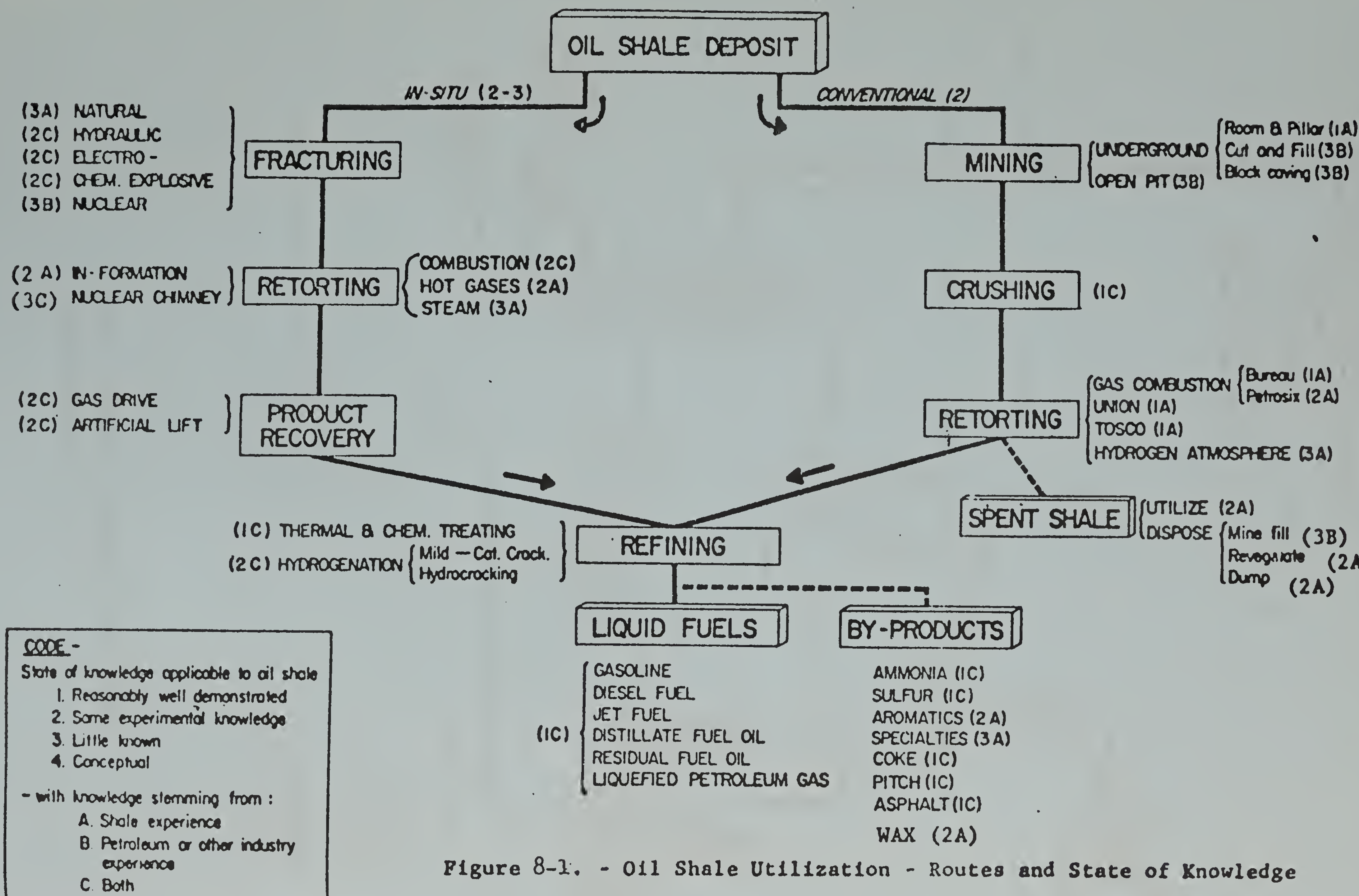

Figure 8-1. - Oil Shale Utilization - Routes and State of Knowledge

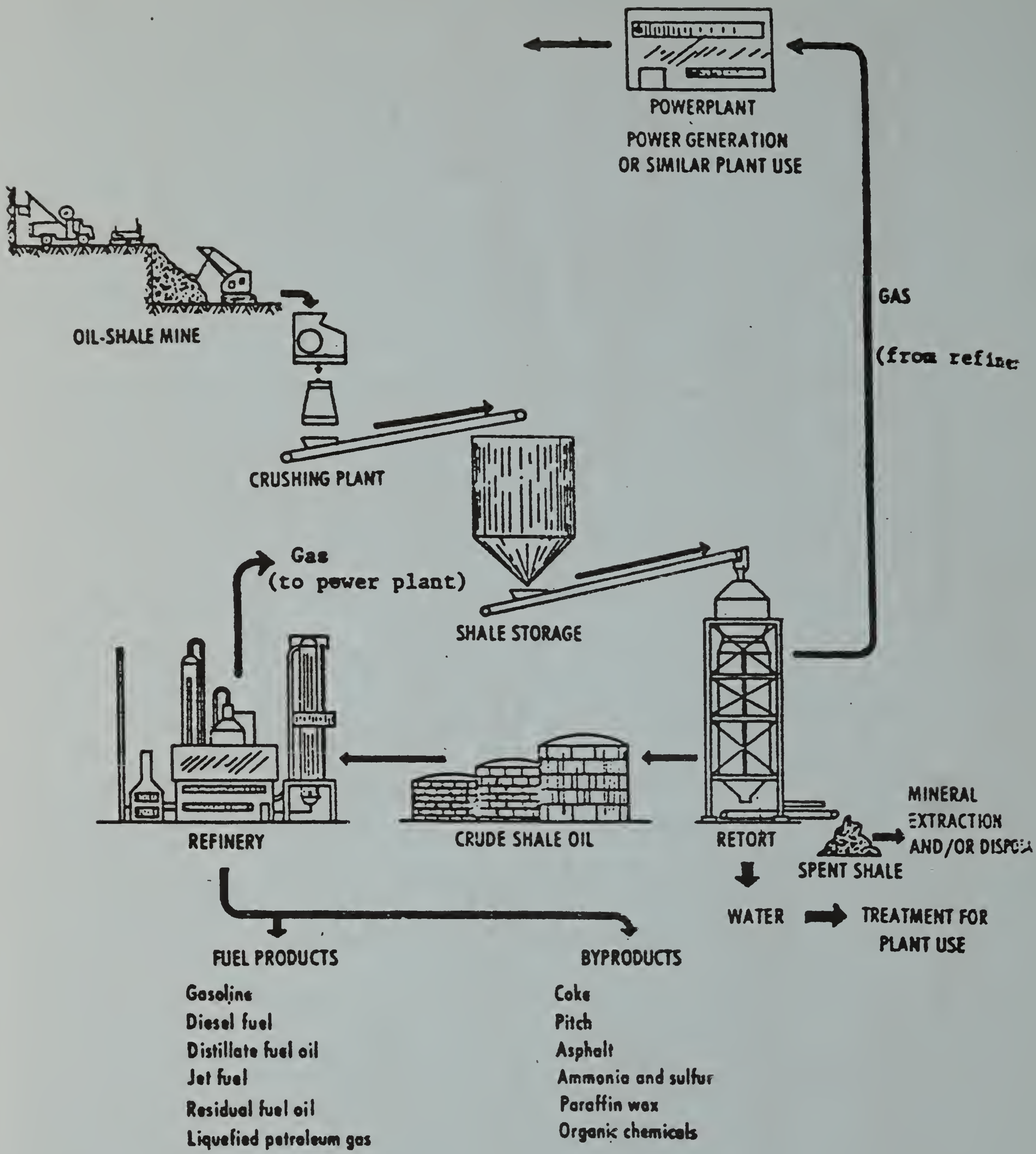

Figure 8-2.–Schematic Diagram of Oil Shale Surface Processing

Oil shale mining can be conducted either at the surface or underground. The former, usually described as open-pit mining, involves removal and disposal of the surface material before the oil shale can be mined. The quantity of overburden material significantly affects the development time and economics. Current open-pit techniques and existing large-scale equipment are expected to enable mine development at relatively low costs, although disposal - restoration costs will be greater than similar costs for underground operations.

The room-and-pillar method has been extensively tested for underground mining of oil shale. In this development plan a maximum of about 75 percent of the shale can be removed. The remainder is left as pillars to prevent surface subsidence. It is expected, however, that some mining, particularly deep mining operations, would provide substantially lower total extraction percentages. Room-and-pillar mining is characterized by large rooms over 60 feet in height, separated by the support pillars. Entry to the oil shale to be mined can be gained either from the surface, by vertical shaft, or by adit..

Regarded as necessary parts of any integrated processing system, crushing and conveying systems are technically well-established, and reasonable in cost. The selection of specific equipment is primarily based on the size of the oil shale fragments needed for subsequent processing.

Literally thousands of retorting processes have been patented worldwide for the production of oil from oil shale. Three processes that have been tested using large experimental equipment appear at this time to offer reasonable possibilities of technical and economic success if scaled up to commercial design size. These retorting methods include the Gas-Combustion process developed by the Bureau of Mines, the Oil Shale Corporation (TOSCO) process, and the Union Oil Company process. In each system, heat is applied to raise the temperature of the oil shale to about 900 degrees F., where the solid organic material (kerogen) is converted to a liquid. The equipment, method of heat application, and operating procedures differ markedly for each system.

Oils from the retorting processes, with the possible exception of the TOSCO process, will require upgrading before the oil can be transported through pipelines to the final product refineries, which are expected to be located outside of the oil shale region. Modern refinery processes are suitable for subsequent upgrading. Each of the three retorts also produces a retort gas that may be used within the plant as a fuel, or alternatively, to generate supplemental electrical power for nearby communities.

Spent shale may be in the form of solid particles ranging from 10 inches in diameter to a fine powder, depending on the retorting

method used. It will normally be dry, but it may be wet if it is processed to recover saline minerals. Disposal will therefore depend on the physical characteristics of the material, its water content, and the location of the disposal area, whether surface or subsurface. If it is to be returned to the mine, this will affect the mine development plans.

Various processes for recovery of the saline minerals associated with the oil shales have been proposed.

The economical recovery of alumina, soda ash, and nahcolite (potentially valuable for removal of sulphur oxides from stack gases) from the deep oil shales has not yet been demonstrated on a large scale, nor have the effects of their recovery been tested by current markets for these chemicals.

An alternate mining and processing technique would involve the recovery of oil from the shale by heating underground, in place. This technique is called in-situ processing and has not been successfully developed or demonstrated on a large scale, although considerable laboratory and field research has been carried out by government and industry.

Presently proposed heat sources for in-situ recovery include underground combustion, hot natural gas, hot carbon dioxide, superheated steam, hot solvents, and combinations of two or more of these. It

is anticipated that conduits for introducing heat underground would be provided by wells, mine shafts and tunnels, fractures created by a variety of techniques, or by a combination of these.

A commercial in-situ processing system has not been demonstrated to date, nor are there any indications that this is a viable technical option in this decade.

d. Environmental Impact

Oil shale development would produce both direct and indirect changes in the environment of the oil shale region in each of the three states where commercial quantities of oil shale resources exist. Many of the environmental changes would be of local significance while others would be of an expanding nature and have cumulative impact. These major regional changes would conflict with other physical resources and uses of the land and water. Impacts would include those on the land itself, the water and air quality, on fish and wildlife habitat, on grazing and agricultural activities, on recreation and aesthetic values, and on the existing social and economic patterns as well as other impacts. The Department's draft environmental statement 1/ has detailed these impacts from both prototype development and a mature industry. The discussion that follows is taken from Volume 1, Chapter V of that analysis.

1/ "Draft Environmental Impact Statement for the Proposed Prototype Oil Shale Leasing Program", September 7, 1972, U. S. Department of the Interior.

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The development of an oil shale industry would require roads, mining, plant sites, waste-disposal areas, utility and pipeline corridors, and associated services during the productive life of a lease. These activities would change the existing pattern of land use and alter the existing topography. Such disturbances would unavoidably exist throughout the life of operations, but would be temporary in the sense that restoration of surfaces to original or improved condition would be required before site abandonment. The cumulative land under development or otherwise not usable would be about 18,000 acres for a 900,000 barrels per day production. Land effects will vary depending on the mining and processing systems that may be used.

Waste disposal areas are generally considered to be in canyon and gully areas which would gradually be converted into flatter areas. Contouring and revegetation would restore scenic attractiveness and probably reduce erosion from the area.

These changes in topography would alter the appearance of the land and would affect natural vegetative cover until revegetation operations began. These changes would be adverse, in the sense that the area's present topography and semi-wilderness character would be altered. The degree to which these topographical changes are adverse, however, is a value judgement difficult to quantify. With proper restoration methods the scenic impact could be kept within acceptable limits. The actual impact would depend on the specific sites that may be chosen for disposal.

Where parts of any lease site areas are now used for livestock grazing, agriculture, wildlife habitat, or recreation, some unavoidable changes in land use patterns would result.

The total impact would be significant in local areas but slight for the region as a whole because the percentage of the region's total surface area affected by development (including urbanization) would be small. However, some local dislocations would unavoidably occur. The extent to which any changes in land use patterns would be adverse are discussed in the sections to follow, together with potential adverse effects on water and air resources.

In order to insure dependable supplies of water from the Colorado River or its tributaries, dams and reservoirs must be constructed, or water must be purchased from existing reservoirs.

The water diverted for all uses would have an unavoidable impact on regional water supplies, because any storage, diversion and net consumption of existing water resources would deplete natural streamflow. This in turn would increase the salinity concentration of the Colorado River at Hoover Dam 5 to 9 mg/l. Other salinity influences could occur from accidental releases, surface water runoff, and water table depression.

During the period between disturbance of the surface and revegetation, high intensity rains could cause accelerated soil erosion and channel cutting and could increase sedimentation in the stream beds. The

cumulative impact of this over time would be quantifiable by sediment measurements of the major rivers. Water discharged into the streams could add to the erosion factor and sediment load.

Drainage courses and channels would probably be diverted because of mine facilities and waste disposal areas. The quantity of impact depends upon the type and intensity of mining operations and control measures used.

As oil shale development proceeds, increased population in all areas would put a greatly increased sanitary waste load on regional water supplies. Even with the best of treatment and disposal facilities this effect cannot be fully mitigated, and in this sense is adverse.

The disturbance of ground water by mining operations, or by water used to return spent shale underground for disposal, could have an adverse effect on subsurface water quality, ground water movement, water levels, spring flow, and streamflow. Knowledge of aquifer characteristics, head relations, and chemical quality distribution in the aquifers in much of the region is inadequate and the extent of this impact cannot be predicted. Specific information developed during core drilling and ongoing research might reduce the risk of adverse impacts on aquifers. Close monitoring of the quality of ground water, and prompt action to change operations detrimental to water quality would help mitigate adverse effects.

Proper techniques already exist to adequately control emissions, including particulates, sulfur oxides, and nitrogen oxides potentially present in various fuel gases, and the dusts produced in mining and shale disposal.

It is expected that all applicable Federal and State criteria on acceptable air quality standards could be met. Residual concentrations of sulfur oxides would total some 205 to 306 tons per day and nitrogen oxides would total 75 to 104 tons per day. Solid particulates in gaseous discharges to the atmosphere would be small, but unavoidable for the program at the present state of technology. New control techniques now being developed for other industrial operations could be incorporated into this industry, which is at least 2, and possible 4 years from construction. Some local problems with temperature inversion may be experience, the significance of which cannot now be established. The long term effect of industrialization would result in a decline in general air quality of the region.

The local noise level at and near the selected sites is expected to increase, due to the mining, retorting, and other processing operations. This is an unavoidable adverse consequence of the increased industrial activity in a region which is presently predominantly a semi-wilderness, and can be only partially mitigated by noise abatement devices.

Construction and operation would have varying degrees of direct and indirect impacts upon fish and wildlife and their habitat in the immediate vicinity of the plants and along their appurtenant roads, surface facilities, and pipelines. Noise and associated human activities accompanying construction and operation would have a new effect of stress and disturbance on normal behavior and activity patterns of wildlife. Depending upon lease site characteristics, species which would be affected by such disturbances include mountain lion, bear, elk, mule deer, antelope, bob cats, sage grouse, blue grouse, and migratory birds. Animal species such as mountain lions, elk, and peregrine and prairie falcons, would be intolerant and areas of up 18,000 acresper year would be completely lost to them as habitat.

Air strips and increases in air traffic would provide some source of aerial harassment of mule deer, wild horses, and big game, the extent of which would be dependent upon the number and location of air strips and the volume of air traffic which would be involved.

Wildlife food and cover values of lands used for mining, pipeline and road construction, building, etc., would be at least temporarily lost. Permanence of such losses would be dependent upon the time required for and success of reestablishing useful wildlife food and cover. Such habitat loss of wildlife production capacity for the developed acres would in turn be reflected in lower populations of

animals. For example, removal of critical winter browse would result in a corresponding reduction in mule deer numbers.

Oil shale-related drying of surface water features, such as springs, seeps, and small streams, would change the natural plant-animal complex associated with each particular water feature, including the related distribution of game, wild horses and cattle.

Coverage of roadside vegetation with vehicle-caused dust would constitute a minor but chronic, problem, since such vegetation would lose its wildlife food value until washed off by subsequent rains.

Unpredicted or uncontrollable changes in the quality of local surface or ground water would result in accompanying impacts on aquatic fish and wildlife populations and their habitat. In the event that sediment, leached substance, saline ground waters and/or toxic materials were released to surface waters as a result of oil shale operations, adverse impacts would be imparted to aquatic plants and animals. Unless carefully controlled such discharges would have adverse effects on aquatic habitat of the Colorado, Green and White Rivers and other exposed water areas. Adverse impacts would also be expected in exposed aquatic habitat in the form of lowered biological productivity, physical covering of fish spawing and nursery areas.

The product oil handling, storage, and transmission system, including feeder pipelines, would exhibit some small losses of oil. Spills would follow natural drainage features and released oil would result in mortality to trees, shrubs, and other vegetation with which it came into contact. Adverse effects would also occur to birds, some species of both land and water mammals, and fish and other aquatic organisms with which the oil came into contact.

Oil shale-related urbanization would also result in some regional adverse impacts upon fish and wildlife and their habitat. Facilitated access and increasing human habitation and activities would result in a region-wide disturbance and stress on wildlife populations. Reductions in surface water quality would occur near population centers, as a result of sewage, toxic substances and siltation and such reductions would have adverse impact upon aquatic organisms and their habitat. Some wildlife habitat would be consumed for buildings, roads, parking lots, etc. Additional wind and water erosion would occur. Increased ground vehicle traffic would result in more frequent road kills of deer and other game.

Increased hunting pressure would cause localized adverse impacts upon wildlife through reduction of populations of some species. Increased harvest of mule deer, elk, moose and antelope would require regulation in order to avoid undesirable downward popula-

tion trends. Region-wide increased hunting pressure would have the most potential for further reductions in very low abundance species, such as brown bear and cougar.

A predictable decrease in the quality of both angling and hunting experience would occur wherever intensified use resulted in fewer and/or smaller fish and game and the physical presence of more hunters or fishermen. One significant effect of a regional oil shale industry would be the net loss of semi-remote hunting and fishing qualities, caused by visual and audio effects of road, vehicular traffic, etc.

Both development and associated urbanization would contribute to those factors which have resulted in the rare and endangered status of several species. If impoundments were constructed on the fast water streams of the humpback chub and Colorado River squaw fish, the presently limited habitat of these species would be further reduced. Adverse effects of herbicides and pesticides introduced to the food chain through localized pest or vegetation control programs would occur but would be expected to be very minor. Such side-effects would be dependent upon the volume and types of chemicals used.

A 900,000 barrel per day oil shale industry would affect annually about 18,000 acres undergoing mining disposal, and restoration, 13,500 to 18,000 acres for human use (residential, etc.) and 1,530 to

1,800 acres for utilities. Based on 30 years of operation, and 18,000 acres affected, these activities would result in a temporary loss of 38 AUM's per year and a loss for the duration of 154 AUM's per year. This is assuming that land used for off-site requirements is largely unavailable for grazing or unsuitable. However, the pipeline corridors are unavailable only temporarily. After re-vegetation the forage production is normally equal or better than before. On the other hand, the changes in life styles or other factors could lead some present livestock operators to reduce ranching activities or cease entirely. While this might not effect actual forage production, it would reduce utilization and effective production of beef.

The new roads, trails, plant sites, waste disposal areas, utility and pipeline corridors which would be part of the prototype oil shale industry would affect the appearance of the present landscape. This is also true of the mining operations, whether underground or on the surface, and applies to in-situ processing as well. The extent of these changes has been reviewed above. The extent to which such alternations in topography could be considered aesthetically adverse is a matter of personal judgement which is difficult to assess quantitatively.

Vegetative rehabilitation success is dependent upon soil quality, water availability, nutrients, and plant vigor. Rarely is the re-established vegetation on disturbed sites as productive or as suitable to wildlife species as the endemic food and cover plants, especially the aspect related to cover and seasonal nutrition values; therefore, long-term reduction in value of the wildlife habitat, and attending recreational opportunity on all seriously disturbed development areas could be expected. Also, during the period between disturbance of the surface and revegetation, high density rains could cause accelerated soil erosion and channel cutting, and could produce increased sedimentation in stream beds, especially those of the free flowing Piceance Creek and White River. Such siltation would have an adverse effect on fishing opportunities and other associated water oriented recreation activities.

Although there are no known historical or archaeological sites on any of the selected tracts, it is a reasonable assumption that the sites or the general area was formerly inhabited by nomadic, hunting, Indian tribes. Any disturbance of the surface, especially an open pit mining operation, could possible disturb some unknown historic archaeological site or artifacts. However, such activities would also increase the probability that such items would be located.

The increased urbanization of a region which is primarily rural, would be an unavoidable consequence of the oil shale development. Since the benefits and costs of urbanized life versus rural life are a matter of personal value judgement, it is impossible to assess the degree to which the social environmental impact would be detrimental. To the degree that urbanization provides diversity of opportunity and choice, the new social changes could be considered beneficial.

10. Wellbore Stimulation for Recovery from Known Deposits

a. Description of the Alternative

Formation "acidizing" and "fracturing" methods are commonly applied in oil and gas wells to stimulate recovery from tight formations and mature fields. Because such wellbore stimulation methods, as conventionally applied, have become an accepted part of producing practices, they cannot be regarded as offering an alternative way of achieving new production.

One innovative method, nuclear stimulation, does have the potential to add materially to the nation's recoverable gas reserves. This method would use nuclear explosives to fracture low permeability gas reservoirs otherwise incapable of sustaining commercial flow rates.

Current emphasis in the U.S. Atomic Energy Commission's Plowshare program is to develop the technology for applying the effects of nuclear explosions to the recovery and utilization of natural resources, primarily natural gas. The program plan is to continue the design and testing of the nuclear explosive, and to assess by field tests techniques for utilizing the effects of multiple nuclear explosives to recover natural gas locked in tight geological formations. Such gas cannot now be economically produced by other methods. 1/

1/ There are some indications of efforts to produce these reservoirs by pressure hydraulic fracturing. Presumably recovery would be lower than after nuclear stimulation, but hydraulic fracturing might offer environmental and economic advantages. Not enough is known of the application to provide a detailed analysis at this time.

Projects Gasbuggy and Rulison are essentially pilot experiments involving the detonation of a single nuclear explosive. Both of these projects are clearly demonstrating that recovery of natural gas by nuclear explosion stimulation is technically feasible and economically promising. The next development phase involves techniques for using multiple explosives in a single wellbore. Gas formations amenable to nuclear explosion stimulation are thicker than can be effectively and feasibly stimulated by a single explosion.

The Atomic Energy Commission has recently reported on the possible scope of nuclear stimulation, and has provided an economic assessment of the technical programs needed to achieve commercially viable application of nuclear stimulation of natural gas wells. The AEC concluded that, based on certain assumptions, "over 10 percent of the Nation's current gas consumption could be met by gas from nuclear stimulation by a development rate of about 50 wells per year". The report indicates, however, that it would take approximately 20 years before gas produced from stimulated reservoirs would be about equal to 10 percent of 1969 consumption. To accomplish this level of production it would be necessary to explode 4,000 nuclear devices of 100-kilotons each in 1,000 wells over the 20 years.

Most natural gas resources amenable to nuclear stimulation are located in the Rocky Mountain region where an approximately 300

trillion cubic feet of gas is estimated to be potentially recoverable using modern technology.

The current development program rate is not expected to provide, in the next ten years, quantities of natural gas that would be meaningful in comparison with present sources of supply.

Discussions of environmental impacts applicable to the current nuclear stimulation program may be found in the Atomic Energy Commission's environmental statements concerning projects in Rio Blanco County, Colorado, and Sublette County, Wyoming.

b. Incremental Production

Assuming successful development of the technology, the AEC estimates that nuclear stimulation could add some 1 trillion or more cubic feet of natural gas to U.S. production per year beginning in the late 1970's or early 1980's.

c. Technological Feasibility of Substitutions

To the extent that natural gas could displace crude oil demand, this method might be considered a partial alternative.

It is not now considered a practical alternative because the commercial technology remains to be developed. Several years of development work need to be carried out before the nuclear stimulation technology will be available for commercial applications.

d. Environmental Impact

The AEC's Plowshare program of nuclear stimulation for increased natural gas production from tight reservoirs will produce no major adverse effects on air quality. There would, however, be some radioactivity associated with the process. This is discussed below.

The chemical composition of the gas in each stimulated well is assumed to be similar to that measured in the first experiments. The initially large carbon dioxide concentration in the chimney would be reduced by dilution with pipeline gas or carbon dioxide would be removed by standard gas field practices. Gas production from the wells could be delayed until short-lived radionuclides decayed. Technical information from subsequent experiments will aid in defining the time for initiation of production.

The remaining gaseous isotopes--tritium and krypton-85--are calculated to provide less than one millirem per year of exposure to the general population if the gas were used as a part of the total gas supply to a large city. No insurmountable problem is anticipated in meeting future regulations or standards developed for sale of the gas. It should be emphasized that the environmental impact of using gas that contains small amounts of tritium will have to be weighted against not having the gas available to augment the Nation's energy resources.

Ground water conditions in a substantial portion of the area which may be developed are well known on the basis of studies already performed. In contemplated development, stimulated zones of broken rock (chimney) would be separated horizontally from each other and vertically from zones containing mobile water by distances generally in excess of 1,000 feet. Thus, each chimney would be an isolated region preventing contamination of ground waters.

The detonation days will be selected to fall outside the principal hunting seasons for the production areas. There should be no effect on the long-term hunting potential of the region. Fishing will be affected only on detonation days in those areas closed.

Some small impact on vegetation will result from road building for access to well sites, and from clearing of drill site areas for drilling and production operations. Drill site locations will return to natural conditions in a short period. This would be similar to conventional gas well drilling and production. The areas affected by natural gas stimulation will be quite small and no significant impact on productive use will occur.

Some slight impact on land use for recreation near development sites will occur, but will be of minimal extent and duration. Additional means of access to isolated regions will increase

opportunities for hunting, fishing, and other recreation activities. After development is completed, no adverse aesthetic effects will be evident. There will be no permanent gas well derricks and very little hardware observable on the surface. Access roads will be of limited extent and public acceptance should be anticipated.

Extension of power and telephone lines can be expected. Gas processing plants, warehousing, and office facilities would be constructed in the area.

The need for local services and materials will have relatively little affect during the first experiments, but as the field development program advances, the need will become greater. Long-term employment associated with full field development could involve hundreds of direct gas industry employees. Current local sources of supplies and services would have to be substantially increased or supplemented. Since much of the work would be conducted year-round, undoubtedly there would be families moving to the areas, causing an increase in such community needs as schools and homes. Additional revenue would be forthcoming to the counties, as well as to the State and Federal Governments.

The development of nuclear stimulation of natural gas reservoirs may be accompanied by some possible damage to existing structures,

due to ground motion. Damages would have to be repaired, or compensation rendered to owners. Ground motion is predictable and utmost care would be used to minimize this effect.

It has been suggested that residual stress from a number of detonations might accumulate and present an earthquake stimulation hazard not present in a single detonation. The best evidence available on this point is from experience with the Nevada Test Site, where data from seismic wave generation and from stimulated fault motion indicate that the cumulative effect of many explosions is to reduce ambient stress levels rather than to increase them. A recent series of high-precision geodolite measurements indicates, also, that the residual strain field around a single explosion site tends to relax with time. In any case, observations of the seismic effects of a series of detonations would permit continuing appraisal of this issue. In the light of present information, it does not appear to constitute an adverse environmental impact.

Adverse environmental impacts for nuclear gas stimulations on a commercial scale should be small in comparison to the benefits to be obtained. Both oil and gas will be needed in increasing quantities in the future. The proposed project in supplemental to other means of increasing natural gas supply. Some quantities of natural gas that would meet clean fuel requirements could be

11. Increase LNG Imports

a. Description of the Alternative

Because of the more than 600:1 volume reduction which occurs when natural gas is liquefied, large volumes of natural gas in a liquefied form are relatively easy to transport and to store. Though natural gas 1/ (LNG) has been liquefied commercially since 1940, in the United States its use until recently has been on a small scale, primarily by gas utility companies for peak-shaving purposes.

Because of the growing shortage of domestic gas supplies, plans are now being made by the gas industry for large LNG imports under long-term contracts. Recently the FPC approved two projects which together call for deliveries of more than 1 billion cubic feet/day of LNG from Algeria. Algeria is currently providing baseload quantities of LNG to England and France.

The following table presents FPC staff's projections of LNG imports to 1980.

LNG Imports 2/

Year	Quantity MMCF/Day
1975	800
1976	1,900

1/ Natural gas becomes a liquid at -259°F at atmospheric pressure.

2/ Federal Power Commission, Bureau of Natural Gas "National Gas Supply and Demand 1971-1990, Staff Report and #2 P. 70.

made available in the 1975-1980 time frame if nuclear gas stimulation technology is vigorously pursued. The public acceptance questions involve in proposals for nuclear stimulation of natural gas reservoirs exceed expected technical or environmental problems.

e. Health and Safety

The production testing technique for current experiments involving initial flaring of gases containing low levels of radioactivity is not contemplated for commercial production. All produced gas is expected to be fed into commercial pipelines.

The depth of the gas formations of interest throughout the Rocky Mountain area is such that the probability of releasing any radiation to the atmosphere at detonation time is very low. Even so, every reasonable precaution would be taken during the field development program to prevent even a slight accidental seepage of radioactive gas to the atmosphere. If an unforeseen seepage of radiation were to occur, previously developed remedial plans would be initiated. Although radiation would not be expected to be detected, long-and short-term radiation monitoring techniques would be employed during field development.

Year	Quantity MMCF/Day
1977	2,700
1978	3,600
1979	4,700
1980	5,500

These figures are based on the assumption that all the projects which have been filed with the FPC, as well as those which have been tentatively proposed by industry, will be in full operation by 1980.

While foreign supplies of natural gas appear to be adequate to meet these requirements, it should be noted that much of U. S. imports of LNG will be from North African areas where political instability could impair the security of supplies.

b. Incremental Production

If production from the proposal is replaced by LNG, imports would have to increase by about 5 billion cubic feet/day. This figure represents the expected gas production of 2.5 billion cu. ft/day, plus 2.5 billion cu. ft./day to substitute for the expected oil production. An increase in imports of this amount would require additional LNG tanker receipts each day.

LNG imports to substitute for this sale would require an increase in either the size or number of regasification plants now being proposed and in the number of LNG tankers. Since an LNG project requires a lead time of about six years, planning should begin at the same time that the sale would have been held.

The cost of the required incremental LNG imports is difficult to project. However, the FPC, in approving the El Paso Natural Gas Co. application to import LNG, limited initial prices to 77¢ per million Btu's delivered at Cove Point, Md. and 83¢ at Savannah, Ga. The company has indicated that the allowed prices may be insufficient.

Even if allowed LNG prices are not increased, LNG will be considerably more costly in East Coast markets than the new gas expected from the proposed OCS sale. The current ceiling price for new gas in the offshore Louisiana area, under the area rate method, is 26¢/Mcf. At this price Louisiana gas can be delivered to New York for about 60¢/Mcf. Thus the area ceiling for new offshore gas could be at least 17¢ higher before reaching parity with LNG.

c. Technological Feasibility of Substitution

Increasing LNG imports to substitute for this proposal would be technologically feasible. LNG processes are well developed. LNG is regasified and distributed in regular natural gas pipeline systems.

Relatively small volumes of LNG would be substituted for the oil expected from this sale. This substitution would be indirect and would present no major problem.

d. Environmental Impact.

In the regasification of the LNG, gas or water will provide the heat for vaporizing the LNG and the release of significant pollutants into the air is not expected. The construction of regasification plants will have a definite impact on land resources. The extent and duration of the impact will depend on the size and location of the plant. For example, a plant now being proposed for Cove Point, MD., would produce initially 650 million cubic feet per day and require a 1,022 acre tract of land. Another plant proposed for Savannah, Georgia, would produce initially 335 million cubic feet per day and require 860 acres. While there will be some disruption of the land surrounding the plant during construction, this disruption should be temporary if proper techniques are used. During construction there will be some damage to animal habitats. This damage will be permanent only in the area occupied by the plant and supporting facilities. Surrounding areas that may be damaged should return to a near-normal condition after construction is completed.

Existing pipelines will be used to transport regasified LNG, if they are available, but new pipelines will be required in some areas. The potential environmental impact due to pipeline construction is examined in the section of this statement dealing with the effect of increasing onshore U. S. gas production.

Each regasification plant will require facilities to permit the transfer of LNG from tankers to storage areas. In the Cove Point case, this will be accomplished by the construction of a mile-long pier into the Chesapeake Bay. At the proposed Savannah plant a channel and a turning basin would be dredged in the Savannah River to allow the tankers to come close to the plant. Both of these methods will require initial dredging, and possibly continued dredging, causing increased turbidity of the water and disruption of bottom sediments. These operations could also disrupt the marine animals, especially in the case of bottom-dwelling organisms. In most cases this disruption would be temporary, but care would have to be taken to avoid, as much as possible, commercial fishing areas.

Since natural gas or water will be used to regasify the LNG, very few pollutants will be released into the nearby body of water. Those plants using water for regasifying the LNG will release the water at a lowered temperature. In the case of the Savannah plant, water temperature will be lowered by 5°F in the vaporizor and then will be

returned to the river. This lower water temperature could be beneficial by allowing the water to hold more oxygen.

A regasification plant could have an impact on the scenic and recreational resources of an area. The choice of the plant site is an important factor in minimizing the impact on scenic qualities and recreational activities. The increase in ship traffic could have an effect on water-oriented recreational activities.

e. Health and Safety

A major concern of any regasification project will be to insure that proper precautions are taken during the handling and storage of the LNG. Though an early LNG plant was destroyed by a disastrous fire in 1944 due to the failure of a storage tank; with a loss of one hundred lives, many improvements have since been made in the technology of storage and handling of the LNG and increased attention has been given to proper safety precautions. The possibility of fire, however, must always be considered in the handling of LNG.

Studies on the possibilities of explosions resulting from LNG spills are inconclusive. Bureau of Mines tests indicate that under certain conditions small-scale explosions result when the LNG is poured onto water. They are not able, however, to predict the result of a large-scale spill on open-water. Another study, by Shell Pipe Line Corporation, concluded that there was no danger of normal LNG exploding

when spilled on water. It felt that explosion would result only after the methane content of the LNG had reached 40%. Since the normal methane content of LNG is 80-90% or more and the boil-off rate is 0.2%-0.3% per day, it felt that with present day shipping practices a reduction to 40% is not possible. 1/ Worldwide experience to date in the handling and shipping of LNG has resulted in no serious explosion or fire. Since 1961, when commercial delivery of LNG by tanker began, there has not been one accident at sea. However, there have been LNG spills reported in certain countries but they have not been serious. Further discussions with the Bureau of Mines also indicate that an explosion resulting from an LNG spill in open water is unlikely.

Another hazard associated with LNG is the possibility of a major fire resulting from spillage or leakage in transportation, transfer and storage. Since spilled LNG would not vaporize instantaneously, the release of the equivalent of several million cubic feet of gas, for example, might cause a fire which would continue until all the LNG had vaporized. The Bureau of Mines also reports that, if there were no fire, the concentration of natural gas in the area of the spill and downwind from the spill would be significantly higher than normal because of the evaporation of some of the lighter hydrocarbons com-

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1/ Shell Oil Company News Release, February 21, 1972.

ponent in LNG. Both of these factors could become significant if a major spill occurred near a heavily populated area.

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12. Synthetic Natural Gas and Oil

a. Description of the Alternative

Through hydrogenation processes, it is possible to convert coal to various hydrocarbon liquid and gaseous substitutes for natural oil and gas. Considerable research and development has been done and further R & D is being conducted by the Federal Government and private industry. While many individual units for commercial gas processes have been tested, synthetic gas has not yet been proved economical in the United States. There are presently no coal-to-liquid conversion plants in the United States. The Department of the Interior's 1972 coal research report (USDI, Office of Coal Research, 1972), describes much of the work currently in progress.

The President, in his Clean Energy Message of June 4, 1971, and in subsequent messages, has given special attention to accelerating development of coal gasification.

The feasibility of producing synthetic natural gas and oil from coal as an alternative to the proposed lease sale depends upon the rates at which technological systems are developed, tested and proved economic and at which commercial scale plants are built. While it is possible that substantial amounts of synthetic fuels could be produced from coal by 1980-1985, the state of technology permits no accurate forecast.

Natural gas can also be synthesized from petroleum. Such gas has been produced commercially in Europe and some 25 plants are in the planning stage for the United States. While the gasification of oil does not add to overall energy supplies, it does provide an additional flexibility in energy form.

b. Coal Gasification

The need for natural gas has been discussed in the section relating to Federal Power Commission natural gas pricing policies. Because of its clean-burning characteristics, gas is the preferred fuel for use in small installations--such as for home heating--where economics preclude the installation of pollution--control equipment.

In the event of limited gas supplies, steam-electric power plants will probably be the first to be denied the use of pipeline-quality gas. Coal can be converted to a clean, low-Btu gas for use under utility boilers. Although such synthetic gas can be piped short distances, it will be more economical to use it adjacent to the gasification plant.

While no coal to pipeline-gas process has yet reached commercial application in the United States, at lease two companies plan to construct a commercial coal-gasification plant using the Lurgi process, which has been known for a number of years, and has been applied commercially in Europe. The earliest date for production from these

projects is 1976. Since gas produced by the Lurgi process has heating value of only 400-450 Btu/cf, catalytic methanation is required to achieve pipeline quality of 1000 Btu/cf for American gas utility use. This step has not yet been commercially demonstrated.

The Department of the Interior and the American Gas Association are cooperating on the accelerated program for coal gasification announced by President Nixon in his Clean Energy Message of June 4, 1971. Two coal gasification pilot plants have been built and are now undergoing shakedown operation, and a third plant has been authorized. In each of the plants a unique gasification method will be tried in conjunction with different systems of gas cleanup and methanation so that a final process, combining the best features of the individual processes can be chosen by the summer of 1975. Construction of a demonstration plant is expected to follow so that a large-scale plant will be on stream by 1977.

Research over a period of fifteen years by the Bureau of Mines has culminated in the development of the "Synthane" process. In June 1971, a contract was let to Lummus for design of a pilot plant; a contract for construction may be let in the autumn of 1972. A draft environmental statement (DES 72-3) was released January 24, 1972. Meanwhile, a smaller pilot plant will be operated by Hydrocarbon Research, Inc., under a contract with the Bureau. The Bureau also

has under review another coal gasification scheme, termed a modified Lurgi process, to use strongly caking coals for making a clean low-Btu gas.

It will require about 5 million tons of coal a year to support one 250 billion Btu per day coal gasification plant (minimum commercial size). The oil and natural gas expected from this proposal should provide about 5500 billion Btu's/day in 1975. Thus, complete substitution by coal gasification would require 22 plants of the 250 billion Btu's per day size. This number of plants would require 132 million tons of coal per year and 22 mines. Estimates for the cost of a plant to process 250 million Btu's/day are about $250 million including the coal mine. Recent estimates by the Office of Coal Research, and the Bureau of Mines, using utility type economics, project a selling price for the gas of about 85-95 cents per MM Btu at the plant. Revisions of these figures can be expected as pilot plant projects are evaluated and technology developed.

c. Oil Gasification

Synthetic natural gas (SNG) can also be produced from petroleum feedstocks. Processes that are being considered include:

1. Thermal cracking in steam.
2. Thermal cracking in a hydrogen-rich atmosphere.
3. Catalytic cracking in steam.
4. Partial oxidation.

Currently, much attention is being given to catalytic rich processes, developed by the British Gas Council. Called the CRG (Catalytic Rich Gas) process, it can gasify a wide variety of hydrocarbon feedstocks, though attention now is concentrated on naphtha feedstocks.

A CRG plant involves two basic operations:

1. Feed preparation, including fractionation and desulphurization.
2. The CRG process, per se, including gasification, and methanation to a gas with a heating value of 980 Btu per cubic foot.

Desulphurization of the feedstock is accomplished by mixing the feed with hydrogen-rich gas, vaporization, and treatment with nickel-molybdate and zinc oxide catalyst. If sulphur is to be recovered, the sulphur-rich fraction is hydrodesulphurized.

About 25 SNG projects, using maphtha feedstocks, have been announced. About half of these state that they intend to operate on imported naphtha. Estimated costs for SNG range from \$1.25 to \$1.75 per MM Btu.

The environmental impacts of such plants are expected to be less than those of comparable coal-based synthesis plants, because they would be free of ash and char, and sulphur oxides and particulates discharge problems.

d. Coal Liquefaction

Until recently, there has not been the same sense of urgency with reference to the conversion of coal to clean-burning oil as exists for pipeline gas. One reason is that imported oil has been available at cheaper prices than a synthetic crude. Also, environmental restraints have forced some electric utilities to abandon the use of coal, or to forego its use in new plants. The supply of low-sulphur coal in the East is limited, additional natural gas for electric utility use is not now available to householders and commercial users, electric utilities may soon be restricted or banned from using natural gas.

Accordingly, the supply problem relating to oil now is being viewed in a more urgent context. The situation, however, as regards the necessity for developing coal-to-oil technology is not yet escalated to an urgent program basis.

The Department of the Interior has filed a Final Environmental Statement, and will soon erect at Fort Lewis, Washington, a Solvent-Refined (SRC) pilot plant. Consideration is now being given to the conversion of Project Gasoline and the pilot plant at Cresap, West Virginia, to test a simplified version of the H-Coal process, and a Bureau of Mines coal conversion process along with others.

Because coal-to-gas, oil-to-gas, and coal-to-liquid fuel plants would be similar in most respects (boilers, reactors, gas scrubbers, etc.) the environmental impacts would be similar. The impacts of transporting these products to market via pipeline has been discussed in an earlier section. The environmental impacts of coal mining have also been discussed and will not be repeated here.

e. Potential Environmental Impact of the Alternatives

Like natural gas, synthetic (also called substitute) natural gas and oil from coal are clean-burning fuels because the sulphur has been reduced to very low values, and no particulate matter is emitted at the point of combustion.

Since there are ample reserves of coal in this country, conversion plants would afford a reliable supply of synthetic fuels for many years, whereby reducing dependence on imported oil and LNG, and concomitantly lessening the potential adverse environmental effect associated with shipping these fuels and delivering them in ports.

Owing to the fact that this report is general, and does not bear on a particular site in the United States, the importance and magnitude of the possible environmental impacts must be estimated. Obviously, the impacts will vary greatly with plant location.

On the basis of some limited pilot plant data, and knowledge of other industrial plants and complexes, some estimates can be made about the principal environmental impacts.

Site preparation and plant erection will have environmental effects; the kinds, importance, and magnitude of which will depend on the site that is selected. Consideration would be given to the effect on factors such as earth, water, flora, fauna, land use, recreation and aesthetics.

Plant operation, consisting of handling and transporting the coal to the process, and converting the coal to gas and/or oil will involve very large quantities of water for cooling and scrubbing gases, and very large quantities of devolatalized coal, called char, which will be burned in boilers to generate process steam and power, or gasified to make process hydrogen. Major emissions that must be controlled are:

1. Sulphur and nitrogen oxides, bottom ash and fly-ash from the plants generating process steam and power. Fly-ash emission from boiler stacks can be controlled, and furnace-bottom ash and slag are handled routinely without environmental problems. However, it may become desirable to locate large coal-conversion plants near large strip mines, where ash and slag from the process would be returned to the open cuts, and the ground restored in accordance with environmental considerations. The technology for controlling sulphur and nitrogen oxides from such plants will be available when the processes become commercial.

2. Contaminated water discharges containing phenols, cresols, benzene, oils, tars, and ammonia gaseous discharges from the Claus tail gas containing some hydrogen sulphide dioxide; and solid discharges such as char and ash; and possibly solids from gas-scrubbing systems using solid sorbents such as dolomite. Process waste waters can be scrubbed free of sulphur compounds. Waste solids such as spect dolomite may present disposal problems in terms of available space and/or surface water contamination, but these are not insurmountable problems.

3. Noise will occur from mechanical equipment, injectors, and pressure-reduction devices, but it is unlikely that it would be a problem beyond the plant property lines.

To illustrate the order of magnitude of the major emissions that would have to be handled from a commercial coal-to-pipeline gas plant, the FPC's National Gas Survey gave the following estimates, based on a plant producing 250 million standard cubic feet per day of pipeline gas* 1/ from coal with 3.7 percent sulphur:

	tons per day
Sulphur (mainly as hydrogen sulphide)	300-400
Ammonia	100-150
Phenols	10-70
Benzene	50-30

1/ This size SNG plant produces the equivalent of 40,000 bbls per day of crude petroleum.

	tons per day
Oil and Tars	trace to 400
Ash (based on coal with 10% ash)	1500

The Federal Power Commission report describes in detail the general means for controlling contaminants in the process waste waters, and the various gas steams.

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13. <u>Reduction in demand</u>

If demand for energy could be reduced sufficiently, the projected oil and gas production from the proposal would be unnecessary. However, it is a misleading simplification to view the choices as either (1) producing about 500 thousand barrels of oil and 25 billion cubic feet of gas per day or (2) reducing demand for energy by this amount. Several considerations invalidate this seemingly logical reasoning: the widening gap between demand and supply of energy from all sources in the near future, the immediate shortage of natural gas, and the limitations from the point of view of technology, cost, and time lag on substitution of other energy sources for oil and gas.

The shortage of natural gas is already evident. FPC estimates that demand for natural gas will exceed supply from all sources (including LNG, coal gas, and pipeline imports) by 3.6 trillion cubic feet in 1975, 9.5 trillion cubic feet in 1980, and 13.7 trillion cubic feet in 1985. The projected production of 2.5 billion cubic feet/day, or approximately one trillion cubic feet a year, is equivalent to only 10% of estimated 1980 unsatisfied demand. Thus, only by reducing demand for natural gas by an amount greatly exceeding the projected lease production would such production be unnecessary.

The demand for energy in the U. S. has been increasing at an average rate of 3.1% annually for the last twenty years, more than twice the growth rate of U. S. population. The United States has both the highest per capita consumption of energy and the highest per capita income in the world. Standard of living and GNP have been correlated to energy consumption. Continued increases in material standard of living tend to be equated with increased number, variety, and size of objects which consume energy in their construction and operation: automobiles, aircraft, refrigerators, air conditioners and the like. In the past, energy growth has been little constrained by price or by supply of resources. However, uncertainty of long-term energy supplies, recognition that environmental costs should be reflected in the price of energy, and concern over environmental quality will affect future energy use.

One approach to reduction in growth of energy demand is reduction in population growth. The association between rapid population growth and rapid economic expansion is no longer valid. The Commission on Population Growth and the American Future states: "We have looked for, and have not found any convincing economic argument for continued national population growth. The average person will be markedly better off in terms of traditional economic values if population growth follows the two-child projection rather than the three-child one." 1/ (Two children per woman approximates long-term Zero Population Growth fertility rate).

1/ Commission on Population Growth and the American Future, Population and the American Future, March, 1972.

U. S. population growth is in a transitional phase and appears to be declining. Population in 1970 was 204 million. Even if family size drops to a two-child average, population will continue to grow, reaching 271 million by 2000. The three-child family would bring the population to 322 million, or 51 million more than the two-child family over the next three decades. 1/

In the short term, reduction in population growth will do little to reduce growth in energy consumption. In a study of electricity demand, alternative population projections showed that "the population assumption is unimportant for demand growth in the next 20 to 30 years". 2/ In addition, the most important factor in growth of energy demand has not been population growth but higher energy use per capita.

The most promising approach to reduction in demand is therefore through lower per capita use of energy. The rate of growth of per capita energy demand could be reduced by (1) reducing the rate of growth of demand for the goods and services produced with energy, (2) producing the demanded goods and services more efficiently, and (3) converting energy to useful work more efficiently. Sectors with great potential for energy savings are residential space heating and cooling and transportation.

1/ Ibid.

2/ Duane Chapman, Timothy Tyrrel, Timothy Mount, Electricity Demand Growth: Implications for Research and Development, June, 1972.

Economics in energy consumption could be realized in space heating and cooling. Electrical power generation is only about 35% efficient and another 10% of generated power is lost in transmission. In contrast, oil fired home furnaces are about 65% to 85% efficient in generating heat. Better insulation could further reduce fuel consumption in homes. Solar heating and heat pumps for home heating require research and development but offer promising possibilities.

A step forward was taken in 1971 with the revision of the Federal Housing Authority's Minimum Property Standards (MPS) for single family dwellings. The MPS establishes thermal design criteria for qualification of residences for FHA-insured mortgages. However, new homes constructed through conventional financing are not required to follow these standards. A study of construction practices found that appreciable energy savings were possible through better insulation. The revised FHA-MPS do not distinquish between electrically heated and combustion heated homes. Consequently, the potential electricity saving afforded by the revised Standards is only 30% of the saving afforded by the economically optimum insulation in the southern region where electric heat is most popular and only 40% in the central region. Additional insulation would afford further energy savings. 1/

1/ John C. Moyers, The Value of Thermal Insulation in Residential Construction: Economics and the Conservation of Energy, Oak Ridge National Laboratory, December, 1971.

The National Wood Insulation Association also projects energy savings by thermal treatment of residences. Two approaches are examined: a "total participation" program and a "reasonably attainable" program. Without better thermal treatment, energy usage for residential space conditioning over the next ten years is estimated at 96,500 trillion Btu's. The reasonably attainable program would cut this amount by 8.5%, the total program by 15.9%.

Thermal insulation also reduces the energy required for air conditioning, an important factor in summer peak loads of utility systems. Different models of air conditioners vary greatly in efficiency. The least efficient consumes 2.6 times the electricity consumed by the most efficient to provide the same cooling. If more efficient air conditioners were used, the annual power consumption for air conditioning in 1970 could have been reduced by 15.8 billion kW-hr, or about 40%. The connected load would have also been decreased by 40%, or by 17,800 MW. 1/

Substantial reductions are also possible in the transportation sector. The transportation of people and goods comprised 24.5% of U. S. energy consumption in 1970. Increases in transportation energy consumption

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1/ Eric Hurst and John C. Moyers, Improving Efficiency of Energy Use: Transportation and Space Heating and Cooling, written testimony submitted to the House Subcommittee on Science, Research and Development, June, 1972.

are due primarily to growth in levels of traffic and shifts to less energy efficient modes. The following tables show energy requirements for transport of freight and passengers. 1/ The efficiencies are typical of the mid-1960's.

Freight Transport

	Btu/ton-mile
Pipeline	450
Waterway	540
Railroad	680
Truck	2,300
Airplane	37,000

Passenger Transport

	Btu/passenger-mile
Bicycle	200
Walking	300
Buses	1,200
Railroads	1,700
Automobile	4,500
Airplane	9,700

The shift from railroads to truck and airplane in freight traffic and from railroad and buses to airplanes has caused declining energy efficiency.

In order to illustrate possible energy savings through use of energy efficient transport modes, one study devised a hypothetical, entirely speculative model which required only 71% as much energy as that actually expended in 1970 to move the same traffic. Although this model ignored factors that inhibit shifts to energy-efficient modes, it shows the magnitude of reduction that is possible. 2/

1/ Eric Hurst, Energy Consumption for Transportation in the U. S., Oak Ridge National Laboratory, June, 1971.

2/ Improving Efficiency of Energy Use: Transportation and Space Heating and Cooling, op. cit.

A report by the Office of Emergency Preparedness 1/ estimated that short-term measures could produce a maximum energy savings of 1.9 quadrillion Btu per year by 1975, equal to 10% of transportation demand. Such measures would include educational programs, establishment of government efficiency standards, improved airplane load factors, smaller engines and vehicles, improved mass transit, and improved traffic flow. Public awareness of energy conservation and alternatives would foster a clearer understanding of the energy implications of decisions. A change in public attitudes toward walking, bicycling, mass transit, electric gadgets, disposable paper goods, bottles and cans, might do much to reduce demand for energy.

Another way to better match supply and demand for energy is through the price mechanism. In the past, use of natural air, water, and land resources has been virtually free. If a price were put on social costs reflecting depletion of resources and damage to the environment, energy would tend to be produced in ways that conserve natural resources. Higher input prices would be passed on as higher output prices, which would reduce demand. This concept underlies such proposals as a tax on auto-emmissions, which could be based

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1/ Executive Office of the President, Office of Emergency Preparedness, Energy Conservation, July, 1972

on number of miles driven and a test on emissions for each vehicle. An auto tax would make it more expensive to drive a car and encourage use of mass transport. In addition, these taxes would provide incentive to develop cleaner technology.

If the costs of environmental and resource use were better reflected in prices of energy, more informed choices could be made. An electric rate schedule including higher charges for peak period usage would encourage consumers to shift use to other times of day, resulting in more efficient use of existing plants and less construction of new generating capacity to service peak demand.

According to one study, 1/ "substantial cost increases and reduction in population growth will noticebly lower electricity demand growth in the 1980's and 1990's. Given the lengthy time period of response, growth reduction in the 1970's might be limited." The authors give the following preliminary estimates of elasticity of electricity demand for electricity prices, income, population, and gas prices.

1/ Electricity Demand Growth: Implications for Research and Development, op. cit.

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Summary of Electricity Demand Estimated Elasticities
for Electricity Prices, Income, Population, and Gas Prices

Factor	Residential	Consumer Class Commercial	Industrial
Average Electricity Price	-1.3	-1.5	-1.7
Population	+ .9	+1.0	+1.1
Income	+ .3	+ .9	+ .5
Average Gas Price	+ .15	+ .15	+ .15
Percent of Response in First Year	10%	11%	11%
Years for 50% of Total Response	8 years	7 years	7 years

The elasticities of demand represent the relationship of the percentage change in electricity demand and the percentage change in the factor. For example, the commercial elasticity for electricity prices of -1.5 means that a 20% rise in average commercial electricity price would in the long run cause demand to be 30% less than it otherwise would have been.

The kind of public policies that would be required to reduce demand, according to Michael McCloskey, Executive Director of the Sierra Club, would include the replacement of the market system to determine how much energy shall be produced or imported and who shall consume energy, with a detailed control on the production, importation, and use of energy in all sectors and regions of the economy. In his

evaluations relative to controlling energy growth, he states:

> "A short-run strategy would involve the following changes in public policy: ending or reducing the many biases in public policies which provide incentives to energy growth; maintaining and strengthening environmental constraints on energy growth; reducing energy demands by educating the public to understand the importance of conservative use of energy; encouraging intensified research and development in order to achieve greater efficiencies in energy utilization and in order to find new, more environmentally acceptable energy sources and discouraging growth in industries that are the most profligate consumers of energy. Coordination of these efforts would be facilitated through the establishment of new government agencies, specifically geared to respond to the energy problem. Each of these changes would involve efforts that would go well beyond the traditional bounds of energy policy, and all could have profound economic and social impacts. Yet changes are already beginning to occur in all these fields, and environmentalists are determined to promote them." 1/

1/ Michael McCloskey, "The Energy Crisis: The Issues and a Proposed Response", Environmental Affairs, Vol. 1, No. 3, Nov. 1971, pp. 587-605.

An evaluation of reduction in demand for natural gas must take into account the present acute shortage of supply. Demand for natural gas is already under restraint due to a variety of controls, including regulatory limitations on new sales (including residential and commerical sales), voluntary restrictions on new sales adopted by gas companies, and the economic restraints inherent in rising retail prices for natural gas. Furthermore, the emphasis being placed on improving air quality is increasing the demand for natural gas because its exhaust contains no sulfur and no particulates. The expected natural gas production from this lease sale would not cause any growth or change in existing patterns of gas consumption. Several pipelines supplied by offshore Louisiana wells have been forced to curtail activities below contracted quantities by amounts in excess of the expected production of natural gas from the lease sale.

If a reduction in demand were directed at the oil and natural gas to be developed from the proposal, all the environmental impacts associated with that development and energy use would be eliminated as a result of the direct tradeoff. It would also eliminate any environmental damages and any adverse results associated with any one of the alternatives to the sale.

A major consideration in restricting demand for energy services is that the cost involved in such a restriction is not related to the environmental damage which would be prevented by not producing, transporting and consuming the energy resources involved. In the case where pollution standards are introduced and enforced, causing the amount of environmental damage to the air per unit of energy produced to decrease radically over the period of a few years, the environmental benefits of the action decline but the associated costs do not.

The following table shows the trend in quantities of air pollutants emitted from mobile equipment using petroleum products. 1/

Estimated Emissions From Mobile Equipment
(millions of tons per year)

	1955	1960	1965	1970	1975	1980	1985
Hydrocarbons							
Autos	9.9	12.0	13.0	11.0	5.9	2.4	0.9
Trucks	1.2	1.4	1.7	1.9	1.7	1.4	1.4
Aircraft	.3	.3	.2	.3	.2	.1	.1
Off-highway	.7	.7	.7	.6	.6	.6	.5
Total	12.1	14.1	15.6	13.8	8.4	4.5	2.9
Carbon monoxide							
Autos	37.3	45.7	55.2	54.3	40.6	24.3	12.7
Trucks & buses	11.1	12.7	15.6	17.4	16.2	14.0	14.2
Aircraft	2.2	1.4	.9	.4	.5	.7	.8
Off-highway	6.7	6.8	5.7	5.3	5.5	4.4	3.4
Total	55.3	66.6	77.4	77.4	62.8	43.3	31.1
Nitrogen oxide							
Autos	3.3	4.0	4.8	5.7	5.0	2.8	1.3
Trucks & buses	.8	.9	1.1	1.4	1.6	1.5	1.7
Aircraft	.01	.01	.03	.05	.06	.08	.09
Off-highway	.8	.9	.9	.9	.9	1.1	1.1
Total	4.9	5.8	6.8	8.1	7.6	5.5	4.2
Particulate							
Autos	.2	.2	.2	.3	.3	.2	.1
Trucks & buses	.1	.1	.1	.2	.2	.2	.2
Aircraft	.01	.01	.02	.04	.04	.04	.05
Off-highway	.2	.2	.2	.2	.2	.2	.1
Total	.5	.5	.5	.7	.7	.6	.5

The impact of the stricter 1968 air pollution standards is quite apparent.

1/ National Petroleum Council (NPC), Environmental Conservation, The Oil and Gas Industry, v. 2, p. 308, February, 1972.

Interpretation of this table shows that an equal reduction in energy demand in 1970 and in 1985 would be more costly in 1985, in terms of energy sacrificed per unit of pollution avoided.

Research and development of more efficient methods of energy extration and use offer long range possibilities for reduction in the amount of input needed to produce a given energy output. In this regard efforts should be directed toward development of total energy processes through which, for example, waste heat discharges could be used to run turbines, for preheating, drying and space heating. Other promising research areas include fuel cells, magnetohydrodynamics and breeder reactors.

A comprehensive study of energy conservation has just been released by the Office of Emergency Preparedness. 1/ The study considers only user conservation and not improvements in recovery techniques or related government actions. If all the suggested measures are implemented, potential annual energy savings by 1980 could be the equivalent of a total of 7.3 million barrles/day of oil; 2.4 million barrels/day in the residential/commerical sector, 2.3 million barrels day in the transportation sector, and 2.6 million barrels/day in the industrial sector. It is significant to note the study's conclusion

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1/ Energy Conservation, op.cit.

that "while the conservation measures proposed in this report will not, taken alone, eliminate the need for increased oil imports, they can substantially reduce this need". Efforts to reduce demand and develop domestic energy resources must be carried forward together.

Procedural and Administrative Policy Alternatives

14. Lease only in KGS areas (Known Geologic Structures) (by competitive leasing only) until technology is developed for better environmental protection for previously undeveloped areas.

One alternative to the present leasing system is to lease only in KGS areas until new technology is developed to protect the environment in previosly undeveloped areas. It is unlikely that this alternative would significantly alter discovery success for the following reasons. Most large onshore geologic structures with potential for oil and gas discoverable economically with current technology have already been identified. Almost all non-competitive leases are issued on wildcat lands, a very large percentage are never even drilled, and success rates are low.

Although discovery rates might not change significantly, restriction of leasing to KGS areas, as they are presently defined, would eliminate a major source of governmental revenue. The number of non-competitive oil and gas leases issued is over five times the number of competitive leases issued. Non-competitive leases generate revenue in the form of application fees ($10 per application), rentals (minimum of $.50 per acre), and royalties ($1 per acre). Further, reasonably safe technology is available today provided that regulations concerning its use are observed. Technology evolves slowly. It is not probable that any revolutionary advances in technology will occur or a failsafe system will be developed. As

gradual technological improvements are made, they can be applied to new leases. When has technology developed far enough to afford adequate environmental protection, especially in previously undeveloped areas, will always be a moot question and one which no single definitive study or technological advance will resolve.

This alternative would, of course, stop further leasing of Federal lands in Oregon since there are presently no known geologic structures within the state.

15. Lease by non-competitive means, but issue no leases in areas shown on Figure 8, Volume 1 as geologically impossible or unfavorable to produce economical deposits of oil and gas.

The environmental impact of this alternative would not differ from that of the present system since leases would still be issued in areas previously leased. Similarly, it is not likely that this alternative would significantly alter discovery rates. Together with other policy changes such as broader definition of KGS areas, this alternative could possibly curtail some of the speculation in non-competitive leases, most of which are never even drilled. However, without other changes, the acreage withdrawn from leasing as unlikely to contain economical deposits is not large enough to significantly limit speculation. More likely, more leases would be issued on other lands to replace those that would have been issued on the withdrawn acreage. The lack of geophysical data on deeper deposits of oil and gas presents difficulties in discovering these deposits and in determining which are "economical." Moreover, the line between economical and uneconomical deposits shifts as the demand for energy and the prices and supplies of energy and energy sources change.

16. Federal Government (through U.S. Geological Survey) takes over all oil and gas exploration activities and offers for competitive leasing, areas found to contain significant deposits of oil or gas and judged to be environmentally feasible for production.

This alternative would give the government more control over rate of development, maintenance of a balance between reserves and production, and selection of tracts. Government decisions could integrate environmental, economic, and political factors such as uniqueness of area, sensitivity to development, and effects of development on regional employment and population. On the other hand, this step would eliminate a large source of revenue - application fees, rentals, and royalties from non-competitive leasing - and at the same time create a great financial burden for the Federal Government. It is uncertain whether bonus payments from competitive leasing of newly discovered deposits would offset this loss of revenue. At present, onshore oil and gas revenues are distributed according to the provisions of the Mineral Leasing Act with 52.5% to the Reclamation Fund, 37.5% to the States and counties, and 10% to the General Treasury. If the Federal Government took over all exploration activities, a new formula for distribution of revenue would be needed that would both compensate the Federal Government for exploration expenses and provide a fair remuneration to the States and counties.

The environmental impacts of this alternative would differ from the present policy to the extent that the Federal Government more

strictly observed environmental regulations, used more up-to-date technology, and restricted exploration and leasing in some areas because of environmental considerations.